01 SOLID FUELS

Sources, winning, properties

12/01090 A study of methodologies for CO_2 storage capacity estimation of coal

De Silva, P. N. K. *et al. Fuel*, 2012, 91, (1), 1–15.
Carbon dioxide (CO_2) capture and storage (CCS) in unmineable coal seams is regarded as one of the possible approaches to mitigate the ever increasing CO_2 concentration in the atmosphere resulting from human activities since the Industrial Revolution. Injection of CO_2 into unmineable coal seams not only provides a solution for long term storage of CO_2 but it also provides the added advantage of enhancing coalbed methane recovery. Adsorption is the main trapping mechanism for CO_2 storage in coal seams where it constitutes to about 95–98% of total storage. Other trapping mechanisms include gas trapped within the matrix structure, free gas and CO_2 trapped as a solute in the pore water. Coal is usually highly heterogeneous and contains pores of different sizes: micropores, mesopores and macropores. The physical properties such as permeability, which usually changes with depth and the degree of cleating, complicates the storage capacity estimation process. Injection of highly dense phase CO_2 may offer higher storage capacity because of its higher density compared to gaseous CO_2. However, there is a lack of verified CO_2 storage capacity estimation methodology for coalbeds. Computing storage potential of CO_2 is not straightforward due to the highly variable coal properties even in the same coal seam. Therefore, in this paper a statistical framework for estimating the CO_2 storage capacity in coal seams is presented with the emphasis on highly dense CO_2 conditions. The approach is based on earlier studies, which utilize important *in situ* parameters to estimate storage capacity in coal seams. These parameters include volatile matter content, moisture, ash, pressure and temperature. Furthermore, several widely used adsorption models for single- and multi-component gas are reviewed. The ability of the various models in predicting the adsorption capacity for different coal types and under various *in situ* conditions was examined. Dataset consists of adsorption data representing 69 coal types having vitrinite reflectance ranging from 0.25% to 3.86%. Results of analyses of this dataset showed that better estimation can be obtained by expressing adsorption capacity as a power function of pressure rather than assuming a linear relationship between adsorption capacity and pressure while keeping other important parameters unchanged.

12/01091 Accessibility of pores in coal to methane and carbon dioxide

Melnichenko, Y. B. *et al. Fuel*, 2012, 91, (1), 200–208.
Fluid–solid interactions in natural and engineered porous solids underlie a variety of technological processes, including geological storage of anthropogenic greenhouse gases, enhanced coal bed methane recovery, membrane separation, and heterogeneous catalysis. The size, distribution and interconnectivity of pores, the chemical and physical properties of the solid and fluid phases collectively dictate how fluid molecules migrate into and through the microporous and mesoporous media, adsorb and ultimately react with the solid surfaces. Due to the high penetration power and relatively short wavelength of neutrons, small-angle neutron scattering (SANS) as well as ultra-small-angle scattering (USANS) techniques are ideally suited for assessing the phase behaviour of confined fluids under pressure as well as for evaluating the total porosity in engineered and natural porous systems including coal. Here, the authors demonstrate that SANS and USANS can be also used for determining the fraction of the pore volume that is actually accessible to fluids as a function of pore sizes and study the fraction of inaccessible pores as a function of pore size in three coals from the Illinois Basin (USA) and Bowen Basin (Australia). Experiments were performed at CO_2 and methane pressures up to 780 bar, including pressures corresponding to zero average contrast condition (ZAC), which is the pressure where no scattering from the accessible pores occurs. Scattering curves at the ZAC were compared with the scattering from same coals under vacuum and analysed using a newly developed approach that shows that the volume fraction of accessible pores in these coals varies between ~90% in the macropore region to ~30% in the mesopore region and the variation is distinctive for each of the examined coals. The developed methodology may be also applied for assessing the volume of accessible pores in other natural underground formations of interest for CO_2 sequestration, such as saline aquifers as well as for estimating closed porosity in engineered porous solids of technological importance.

12/01092 Assessing the conditions favorable for the occurrence of gas hydrate in the Tuonamu area Qiangtang basin, Qinghai–Tibetan, China

He, J. *et al. Energy Conversion and Management*, 2012, 53, (1), 11–18.
Qiangtang basin, which is located in the largest continuous permafrost area in Qinghai–Tibetan plateau, is expected to be a strategic area of gas hydrate exploitation in China. However, relatively little work has been done on the exploration of gas hydrate in this area. In this work, the authors evaluated the factors controlling the formation of gas hydrate in the Tuonamu area and provided a preliminary insight into gas hydrate distribution in it on the basis of the core samples, seismic data and laboratory analysis. It can be concluded that the source rock in the deeper formation would be dominant thermogenic source for the formation of gas hydrate in Tuonamu area. The thickness of gas hydrate stable zone in this area is about 300 m. The gas hydrate in the area most probably is in the form of gas-hydrate-water. The source condition is the key factor for the formation of gas hydrate and the gas hydrate layer would be mainly present in the form of interlayer in this area. The areas around the deeper faults are the favourable targets for the exploration of gas hydrate in the Tuonamu area.

12/01093 Comparison among nonlinear excitation control strategies used for damping power system oscillations

Leon, A. E. *et al. Energy Conversion and Management*, 2012, 53, (1), 55–67.
This work is focused on the problem of power system stability. A thorough description of non-linear control strategies for synchronous generator excitation, which are designed for damping oscillations and improving transient stability on power systems, is presented along with a detailed comparison among these modern strategies and current solutions based on power system stabilizers. The performance related to damping injection in each controller, critical time enhancement, robustness against parametric uncertainties, and control signal energy consumption is analysed. Several tests are presented to validate discussions on various advantages and disadvantages of each control strategy.

12/01094 Difference in chemical composition of supercritical methanolysis products between two lignites

Chen, B. *et al. Applied Energy*, 2011, 88, (12), 4570–4576.
Dehydrated Xilinhaote lignite (XL) and Huolinguole lignite (HL) were depolymerized in supercritical methanol at 310 °C and the resulting soluble reaction mixtures were analysed with GC/MS. The results show that the GC/MS-detectable species can be classified into hydroxybenzenes (HBs), esters, ketones, alkanols, arenes, methoxybenzene, alkanes, alkenes, nitrogen-containing organic compounds, sulfur-containing organic compounds, aldehydes and other compounds. However, the difference in the product yield from different coals is significant. The most abundant products are HBs from XL and esters from HL.

12/01095 NO_x reduction from a large bore natural gas engine via reformed natural gas prechamber fueling optimization

Ruter, M. D. *et al. Fuel*, 2012, 91, (1), 298–306.
Lean combustion is a standard approach used to reduce NO_x emissions in large bore (35–56 cm) stationary natural gas engines. However, at lean operating points, combustion instabilities and misfires give rise to high total hydrocarbon (THC) and carbon monoxide (CO) emissions. To counteract this effect, precombustion chamber (PCC) technology is employed to allow engine operation at an overall lean equivalence ratio while mitigating the rise of THC and CO caused by combustion instability and misfires. A PCC is a small chamber, typically 1–2% of the clearance volume. A separate fuel line supplies gaseous fuel to the PCC and a standard spark plug ignites the slightly rich mixture (equivalence ratio 1.1–1.2) in the PCC. The ignited PCC mixture enters the main combustion chamber as a high energy flame jet, igniting the lean mixture in the main chamber. Typically, natural gas fuels both the main chamber and the PCC. In the current research, a mixture of reformed natural gas (syngas) and natural gas fuels the PCC. Syngas is a broad term that refers to a synthetic gaseous fuel. In this case, syngas specifically denotes a mixture of hydrogen, carbon monoxide, nitrogen, and methane generated in a natural gas reformer. Syngas has a faster flame speed and a wider equivalence ratio range of operation than methane. Fuelling the PCC with syngas reduces combustion instabilities and misfires. This extends the overall engine lean limit, enabling further NO_x reductions. Research results presented are aimed at quantifying the benefits of syngas PCC fuelling. A model is developed to calculate the equivalence ratio in the PCC for different mixtures and flowrates of fuel. An electronic injection valve is used to supply the PCC with syngas. The delivery pressure, injection timing, and flow rate are varied to optimize PCC equivalence ratio. The experimental results show that supplying the PCC with 100% syngas improves combustion stability by 21% compared to natural gas PCC fuelling. A comparison

at equivalent combustion stability operating points between 100% syngas and natural gas shows an 87% reduction in NO_x emissions for 100% syngas PCC fuelling compared to natural gas PCC fuelling.

12/01096 On the deduction of single coal particle combustion temperature from three-color optical pyrometry

Khatami, R. and Levendis, Y. A. *Combustion and Flame*, 2011, 158, (9), 1822–1836.

Temperature–time histories of burning single coal particles can be obtained with multi-colour (multi-wavelength) optical pyrometry. With this method, a number of different temperatures can be deduced from the resulting number of two-colour ratios. However, these two-colour temperatures do not always agree, causing considerable uncertainty in the temperature measurement. This work used a three-color pyrometer and focused on identifying and minimizing the causes of disparity among the three deduced temperatures. Components of the pyrometer (such as dichroic filters, interference filters and photo-detectors) were modelled mathematically, taking into account their wavelength-dependent properties. The pyrometer was calibrated with both a high-temperature pre-calibrated tungsten lamp, and a moderately high temperature blackbody cavity, to span the temperature range of interest in pulverized coal combustion. Temperatures were deduced based not only on a suitably modified pyrometric signal ratio method but also, on a similarly modified pyrometric signal non-linear least-square method, to provide comparison. Results are exemplified by presenting radiation-signal-time and temperature–time profiles of single particles burning in air. The variation of the projected luminous area of burning particles was also computed using both methods, and area–time profiles are presented herein. The char particle emissivity was either treated as a quantity independent of the wavelength (i.e. assuming grey-body behaviour), or as a quantity assumed to depend linearly on the wavelength and using pertinent published emissivity data. Finally, a sensitivity analysis was performed to investigate individual effects of parameters, such as the calibration method, the wavelength dependencies of filter transmissivities, and the photo-detector responsivities on the pyrometric signal ratio method temperature consistency.

12/01097 Simultaneous thermogravimetry–calorimetry study on the combustion of coal samples: effect of heating rate

Kok, M. V. *Energy Conversion and Management*, 2012, 53, (1), 40–44.

Combustion characteristics of two different coal samples were investigated using power compensating type differential scanning calorimeter (DSC) and thermogravimetry (TG–DTG) at different heating rates (5, 10 and 15 °C/min). Differential scanning calorimeter (DSC) and thermogravimetry (TG–DTG) curves revealed two main reaction regions at each heating rate studied. Reaction regions, peak and burn-out temperatures, weight loss and heat of reactions of the samples were determined. Kinetic parameters of the coal samples were also determined by different methods and it was observed that the activation energy values of the coal samples were in the range of 27.2–76.2 kJ/mol for different reaction regions studied.

Preparation

12/01098 A predictive kinetic model of sulfur release from coal

Maffei, T. *et al. Fuel*, 2012, 91, (1), 213–223.

The aim of this paper is to present a predictive kinetic model of the release of sulfur compounds from coal. The model first characterizes the relative amount of the different forms of sulfur components. Inorganic (pyritic and sulfates) and organic sulfur (aliphatic, aromatic and thiophenic) are estimated quite simply on the basis of a wide range of elemental coal compositions available in the literature. Sulfur compounds are released in the gas phase mainly as H_2S and S components in the tar fraction. A sulfur fraction also remains in the residual char. The kinetic model, with the related rate parameters, is validated through comparison with experimental data from the literature. The agreement is satisfactory, even though further experimental and theoretical investigation would be useful to improve the reliability of this kinetic model still further.

12/01099 Combustion and emissions behavior for ethanol–gasoline blends in a single cylinder engine

Schifter, I. *et al. Fuel*, 2011, 90, (12), 3586–3592.

This paper investigates the effect of using gasoline–ethanol mid-level blends (0–20% ethanol) on engine performance and exhausts emissions on a single cylinder engine by AVL model 5401, spark ignited and electronically controlled with DOHC. Engine tests were conducted for different lambda values, brake power and brake specific fuel consumption, while exhaust emissions were analysed for carbon monoxide, unburned hydrocarbons and nitrogen oxides. Using blends at different proportions for a steady state of 2000 rpm at partial charge minimizing load and speed variations at a minimum in order to prevent them from being a measurable factor. Results showed that at constant mass fuel rates, the increase in burning rate associated with ethanol is tempered by the process combustion speed reduction related to the enleanment proportional to the ethanol added to gasoline. Blends up to 10% have marginal effects in combustion rates when compared to non-oxygenated fuels, but for 20%, combustion process slows down and increases cyclic dispersion in the results, the effect in fuel consumption observed was lower than predicted by the reduction of energy content in the gasoline, suggesting positive effects in combustion efficiency.

12/01100 Use of a single-zone thermodynamic model with detailed chemistry to study a natural gas fueled homogeneous charge compression ignition engine

Zheng, J. and Caton, A. *Energy Conversion and Management*, 2012, 53, (1), 298–304.

A single zone thermodynamic model with detailed chemical kinetics was used to simulate a natural gas-fuelled homogeneous charge compression ignition (HCCI) engine. The model employed Chemkin and used chemical kinetics for natural gas with 53 species and 325 reactions. This simulation was used to complete analyses for a modified 0.4-litre single cylinder engine. The engine possessed a compression ratio of 21.5:1, and had a bore and stroke of 86 and 75 mm, respectively. Several sets of parametric studies were completed to investigate the minimal initial temperature, engine performance, and nitric oxide emissions of HCCI engine operation. The results show significant changes in combustion characteristics with varying engine operating conditions. Effects of varying equivalence ratios (0.3–1.0), engine speeds (1000–4000 rpm), EGR (0–40%), and fuel compositions were determined and analysed in detail. In particular, every 0.1 increase in equivalence ratio or 500 rpm increase in engine speed requires about a 5 K higher initial temperature for complete combustion, and leads to around 0.7 bar increase in IMEP.

Transport, storage

12/01101 Coal lumps vs. electrons: how do Chinese bulk energy transport decisions affect the global steam coal market?

Paulus, M. and Trüby, J. *Energy Economics*, 2011, 33, (6), 1127–1137.

This paper demonstrates the ways in which different Chinese bulk energy transport strategies affect the future steam coal market in China and in the rest of the world. An increase in Chinese demand for steam coal will lead to a growing need for additional domestic infrastructure as production hubs and demand centres are spatially separated, and domestic transport costs could influence the future Chinese steam coal supply mix. If domestic transport capacity is available only at elevated costs, Chinese power generators could turn to the global trade markets and further increase steam coal imports. Increased Chinese imports could then yield significant changes in steam coal market economics on a global scale. This effect is analysed in China, where coal is mainly transported by railway, and in another setting where coal energy is transported as electricity. For this purpose, a spatial equilibrium model for the global steam coal market has been developed. One major finding is that if coal is converted into electricity early in the supply chain, worldwide marginal costs of supply are lower than if coal is transported via railway. Furthermore, China's dependence on international imports is significantly reduced in this context. Allocation of welfare changes particularly in favour of Chinese consumers while rents of international producers decrease.

12/01102 Impact of the installation scenario of porous fences on wind-blown particle emission in open coal yards

Cong, X. C. *et al. Atmospheric Environment*, 2011, 45, (30), 5247–5253.

As a common solution, porous fences are used to reduce the fugitive particulate emission from store piles aggregated in the open storage yards of harbour areas. The dust dispersion has caused heavy ecological pollution and economic losses. In this paper, taking the open coal yard in Caofeidian Port as an example, CFD technology was employed and the flow characteristics over the surfaces of stockpiles were simulated using the $k-\varepsilon$ RNG turbulence closure model. To validate the boundary conditions defined in the simulation, a field measurement campaign was carried out and the experimental results verified the predicted ones. A more detailed formulation for dust emission compared to the EPA mode was developed afterward to evaluate dust emissions by the CFD approach. The results confirmed the role of porous fences in reducing the dust emissions by comparing the average emission coefficients of four possible installation scenarios proposed from the local wind flow characteristics. It was found that, for variable wind conditions tested during a whole year, dust emissions reduction was approximately 85% in all enclosure along the yard, and the value was 55% and 65% respectively when installing two-side and three-side protection scenarios against the windward of dominant wind direction. This study may suggest some meaningful implications to understand the shelter effect differences among the installation scenarios of porous fences from the technical view.

Economics, business, marketing, policy

12/01103 China's coal policy since 1979: a brief overview

Shen, L. *et al. Energy Policy*, 2012, 40, 274–281.

Since reform and opening-up in 1978, the coal industry in China has been developing rapidly. This article identified major factors affecting the growth of China's coal industry, immediate targets, economic policies, as well as structural reforms of the sector. Authors have divided its developing process into three stages: rapid growth of coal industry (1979–1992); close-down of small-scale coal mines (SCMs) (1993–2001); resource consolidation (2002–present). At the first stage, led by the 'two-leg walking' strategy, SCMs grew significantly, which eased the pressure of energy shortage. From the transition of planned economy to market economy, major state-owned coal mines (MSCs), which were not consistently profitable, would have to learn how to withstand severe competitions and survive. As a result, the central government took several measures to try to keep them alive. This situation was not changed until 2001. Large-scaled coal mine groups were then established by the government when China entered the WTO. MSCs were encouraged to merge with others to form a certain scale, as a way to compete with giant overseas. So a trial was firstly implemented in Shanxi province.

12/01104 Coal consumption and economic growth in China

Li, R. and Leung, G. C. K. *Energy Policy*, 2012, 40, 438–443.

The aim of this paper is to re-examine the relationship between coal consumption and real gross domestic product (GDP) of China with the use of panel data. This paper applies modern panel data techniques to help shed light on the importance of the heterogeneity among different regions within China. Empirical analyses are conducted for the full panel as well as three subgroups of the panel. The empirical results show that coal consumption and GDP are both I(1) and cointegrated in all regional groupings. Heterogeneity is found in the GDP equation of the full panel. The regional causality tests reveal that the coal consumption–GDP relationship is bidirectional in the coastal and central regions whereas causality is unidirectional from GDP to coal consumption in the western region. Thus, energy conservation measures will not adversely affect the economic growth of the western region but such measures will likely encumber the economy of the coastal and central regions, where most of the coal intensive industries are concentrated.

12/01105 The globalization of steam coal markets and the role of logistics: an empirical analysis

Zaklan, A. *et al. Energy Economics*, 2012, 34, (1), 105–116.

In this paper, a comprehensive multivariate cointegration analysis is provided of three parts of the steam coal value chain: export, transport and import prices. The analysis is based on a rich dataset of international coal prices; in particular, data are combined on steam coal prices with freight rates, covering the period December 2001 until August 2009 at weekly frequency. The authors then test whether the demand and supply side components of steam coal trade are consistently integrated with one another. In addition, export and import prices as well as freight rates for individual trading routes, across regions and globally are combined. The authors find evidence of significant yet incomplete integration and also heterogeneous short-term dynamics of individual markets. Whether logistics enter coal price dynamics is considered through transportation costs, which are mainly determined by oil prices. The results suggest that this is generally not the case.

02 LIQUID FUELS

Sources, properties, recovery

12/01106 Detailed and reduced chemistry for methanol ignition

Seiser, R. *et al. Combustion and Flame*, 2011, 158, (9), 1667–1672.

Simplified chemical-kinetic mechanisms are sought that can provide agreement with measured shock-tube autoignition times and counterflow critical ignition conditions for methanol (CH_3OH) oxidation. Existing detailed chemistry over-predicts measured counterflow ignition temperatures by 100 K or more. It was found that the elementary step $CH_3OH + HO_2 \rightarrow CH_2OH + H_2O_2$ most strongly affects the predictions. Increasing the pre-factor in the Arrhenius expression for the rate of this step from different available literature values by a factor ranging from 2 to 13, namely to 8×10^{13} cm^3/(mol s), within existing uncertainty, produces agreement of predictions with experiment. Using this revised rate, unimportant steps are deleted from the San Diego mechanism to obtain a set of 26 irreversible elementary steps (augmented to 27 by including fuel dissociation to $CH_3 + OH$ for high-temperature shock-tube conditions) that predict ignition nearly as well as the detailed mechanism. In this mechanism, the intermediate species CH_2OH, CH_3O, HCO, H, O, and OH accurately obey steady states, while the intermediates CH_2O, HO_2, H_2O_2, CO, and H_2 do not. The result is a six-step overall reduced mechanism that describes ignition well at the lower temperatures. At higher temperatures, the aforementioned fuel decomposition becomes important, increasing the six-step mechanism to a seven-step mechanism. Expressions for the reaction rates, branching ratios, and steady-state species concentrations in the six-step reduced mechanism are given to facilitate future methanol ignition computations. Higher alcohols, which are less dependent on HO_2 attack in ignition, are indicated to nevertheless possibly benefit from an increase of the rate of the corresponding step.

12/01107 Electrochemical impedance spectroscopy for *in situ* petroleum analysis and water-in-oil emulsion characterization

Perini, N. *et al. Fuel*, 2012, 91, (1), 224–228.

The measurement of electrochemical impedance spectroscopy used *in situ* is a suitable technique for the characterization of oil and water-in-oil emulsions. Nyquist diagrams for dehydrated oils are characterized by the formation of one semi-circle. The equivalent circuit proposed for the dehydrated oil is a resistance and capacitor ($R_O C_O$) in parallel. The resistance and conductivity of the oil calculated by impedance were 2.96 GΩ and 486 nS m^{-1}, respectively. Nyquist diagrams for the system composed of water emulsions in oil are mainly characterized by two semi-circles with different relaxation for oil and water-in-oil emulsions. The equivalent circuit is formed by R_O and $\mathrm{CPE_O}$ in parallel and in series with the arrangement of $R_{W/O}$ and $\mathrm{CPE_{W/O}}$ in parallel, where R_O and $\mathrm{CPE_O}$ represents the oil, and $R_{W/O}$ and $\mathrm{CPE_{W/O}}$ represents water-in-oil emulsions. The resistance of oil (R_O) and water-in-oil ($R_{W/O}$) emulsions increase with the increasing amount of water in the preparation. The increase in resistance shows that the emulsions become more stable with the addition of water. This result is consistent with the formation of rigid films on water–oil interfaces. The impedance measurements were applied to the analysis of the demulsification of the water-in-oil emulsions under an electrostatic field.

12/01108 Thermo-oxidative characterization and kinetics of tar sands

Kok, M. V. *Energy*, 2011, 36, (8), 5338–5342.

In this research, non-isothermal kinetics and thermal analysis of Gerçüş tar sand sample is studied by DSC (differential scanning calorimeter) and TG/DTG (thermogravimetry). Experiments were performed using three different mesh size (20–35, 35–50 and >50) of sample. Differential scanning calorimeter (DSC) curves revealed three reaction regions in the temperature range of 20–600 °C. On the other hand, thermogravimetry (TG/DTG) curves of tar sand samples at different particle sizes demonstrated three stages of weight loss. Two different kinetic models (Coats & Redfern and Arrhenius) were used to determine the kinetic parameters of the samples and it was observed that the average activation energy values were between 17.5 and 26.6 kJ/mol, for reaction region-II and 126.2–160.1 kJ/mol for reaction region-III, respectively. In order to see the contribution of each region to the overall reactivity of the tar sand sample, weighted mean apparent activation energy of the samples are also determined.

Transport, refining, quality, storage

12/01109 Investigating the trade-off between operating revenue and CO_2 emissions from crude oil distillation using a blend of two crudes

Al-Mayyahi, M. A. *et al. Fuel*, 2011, 90, (12), 3577–3585.

Blending of different crude types is frequently used in petroleum refineries to improve their profitability and products yields. However, energy consumption and consequential carbon dioxide emissions strongly depend on the types of crude being processed. The trade-off between carbon dioxide emissions and economic objectives, such as net revenue, is investigated for cases of different crude blends using the multi-objective optimization approach. The first objective is the minimization of carbon dioxide emissions while the second objective is maximizing the net revenue from the crude distillation unit (CDU). A rigorous model is used to estimate carbon dioxide emissions from different sources within the CDU. This emissions model incorporates pinch analysis for heat integration, to optimize the distribution of utilities related to emissions. Blends of two crudes, 36 API and 27.7 API, are used as feedstock to a rigorous CDU model of the atmospheric crude tower, vacuum tower and heat exchanger network. Lighter crude blends recorded higher carbon dioxide emissions and net revenue compared with the heavier blend due to the greater distilled fraction. However, carbon dioxide emissions did not vary linearly with the fraction of each crude, as the heat exchanger network also influenced the degree of heat recovery and consequently the level of carbon dioxide emissions. The multi-objective solutions show the influence of all 13 of the process variables on the objectives.

12/01110 Kinetics of oil and oil products adsorption by carbonized rice husks

Angelova, D. *et al. Chemical Engineering Journal*, 2011, 172, (1), 306–311.

Composite C/SiO_2 containing material has been obtained by pyrolysis of rice husks, carried out at a temperature of 480 °C. The material has been studied as adsorbent for purification of pollutions caused by oil and oil products. The amount and composition of the fluids, dispersed on the surface of the carbonized rice husks, has been determined applying extraction and gas chromatography–mass spectrometry method (GC–MS). The material has been characterized also with respect to the specific surface area by Brunauer–Emmett–Teller (BET) method and mercury porosimetry. Adsorption capacity of the pyrolysed rice husks was determined in respect of water, oil and petroleum products with different densities. The material obtained by pyrolysis of rice husk has very good buoyancy characteristics, high oil sorption capacity and high hydrophobicity. The influence of the bulk density of the sorbent has been investigated as well as that of the density of the oil product on the kinetics and mechanism of sorption. It was established that the dependence between the bulk density of the adsorbent and the height of penetration of the oil in it for a specified time is inversely proportional. The height of penetration of the sorbate in the sorbent layer depends on the density of the liquid phase. The changes of the adsorption rate for the various oil products can be described by hyperbolic dependence. A correlation between surface functional groups and morphology of the adsorbent and adsorption properties of the material was created. The research provides the basis for development of a new environmental material with optimal characteristics, providing efficient adsorption of oil and oil products from aqueous medium.

12/01111 Storage effect in the quality of different methyl esters and blends with diesel

Berrios, M. *et al. Fuel*, 2012, 91, (1), 119–125.

Storage stability is an important aspect in the commercialization of biodiesel. Due to the chemical structure of methyl ester, long-term storage may lead to the degradation of fuel properties that can make it difficult to meet the EN 14214 Standard. This paper examines the degradation of several biofuels (sunflower methyl esters, used cooking oil methyl esters and blends with commercial diesel) under different storage conditions over a 6-month period. The storage conditions simulated real-life conditions by using similar temperatures to those found in commercial tanks, with little air turnover and in the absence of light. Extreme temperature conditions were also studied to determine if this variable has an effect on storage stability. Opaque glass or stainless steel storage containers were used to check the interaction between metal and biofuel. The results show that temperature plays an important role in the degradation of methyl esters. On the other hand, stainless steel was found to be a suitable material for the commercial storage tanks as the effect of this material on stability was almost negligible. The blends with commercial diesel performed better in long-term storage. This was probably due to the effect of the ester dilution and the presence of additives in commercial diesel.

Economics, business, marketing, policy

12/01112 Abatement costs of CO_2 emissions in the Brazilian oil refining sector

Castelo Branco, D. A. *et al. Applied Energy*, 2011, 88, (11), 3782–3790.

This study aims at estimating the abatement costs of CO_2 emissions of the Brazilian oil refining sector. For greenfield refineries that will be built until 2030, mitigation options include the modification of refining schemes and efficiency gains in processing units. For existing refineries and those already under construction, only mitigation options based on efficiency gains in processing units are evaluated. The abatement cost of each mitigation option was determined on the basis of incremental costs compared with a reference scenario. Two discount rates were applied: one adopted by the Brazil's government official long-term plan (8% p.a.), and another typically adopted by the private oil sector (15% p.a.). Findings indicate that refineries face high abatement costs. The cost of changing the processing scheme of greenfield plants reaches US\$100/tCO_2 at 15% p.a. discount rate. Even at 8% p.a. discount rate the abatement cost is higher than US\$50/tCO_2. The most promising alternative is thermal energy management, whose abatement cost equals US\$20/tCO_2 at 8% p.a. discount rate. However, private investors perceive this option at US\$80/tCO_2, which is still high. This difference in cost indicates the need for public policies for promoting carbon mitigation measures in Brazilian oil refineries.

12/01113 Assessing the impact of US ethanol on fossil fuel markets: a structural VAR approach

McPhail, L. L. *Energy Economics*, 2011, 33, (6), 1177–1185.

Despite the growing importance of biofuels, the effect of biofuels on fossil fuel markets is not fully understood. This paper develops a joint structural vector auto regression (VAR) model of the global crude oil, US gasoline, and US ethanol markets to examine whether the US ethanol market has had any impact on global oil markets. The structural VAR approach provides a unique method for decomposing price and quantity data into demand and supply shocks, allowing the estimation of the distinct dynamic effects of ethanol demand and supply shocks on the real prices of crude oil and US gasoline. Ethanol demand in the US is driven mainly by government support in the form of tax credits and blending mandates. Shocks to ethanol demand therefore reflect changes in policy more than any other factor. In contrast, ethanol supply shocks are driven by changes in feedstock prices. A principal finding is that a policy-driven ethanol demand expansion causes a statistically significant decline in real crude oil prices, while an ethanol supply expansion does not have a statistically significant impact on real oil prices. This suggests that even though US ethanol market is small, the influence of US biofuels policy on the crude oil market is pervasive. The authors also show that ethanol demand shocks are more important than ethanol supply shocks in explaining the fluctuation of real prices of crude oil and US gasoline.

12/01114 Coal liquefaction policy in China: explaining the policy reversal since 2006

Rong, F. and Victor, D. G. *Energy Policy*, 2011, 39, (12), 8175–8184.

China has emerged as a leader in coal liquefaction. While the country's abundant coal resources and acute concerns about oil security help explain China's interest in liquefaction, the driving forces for this industry are complicated and policy has been inconsistent. Since 2006 Beijing has tried to slow down the development of liquefaction; even as China has become more dependent on imported oil, the central government has been wary about the large impact of liquefaction technologies on scarce resources such as water. However, local government officials in coal rich areas have strong incentives to pour investment into the technology, which helps explain the uneven development and policy. The future of coal liquefaction will depend on how these forces unfold along with major Beijing-led reforms in the Chinese coal industry, which is closing smaller mines and favouring the emergence of larger coal producing firms. Those reforms will have mixed effects on liquefaction. They temporarily contribute to higher prices for coal while over the longer term creating coal companies that have much greater financial and technical skills needed to deploy technologies such as coal liquefaction at a scale needed if this energy pathway is to be competitive with conventional sources of liquid fuel.

12/01115 Development trends in the Azerbaijan oil and gas sector: achievements and challenges

Ciarreta, A. and Nasirov, S. *Energy Policy*, 2012, 40, 282–292.

This article is study of Azerbaijan oil and gas industry. It illustrates the business climate, the impact of this sector on Azerbaijan's economy including role of SOFAZ and highlights recent developments in the energy production and the main concepts of Azeri PSAs (2009). Meanwhile, the article establishes the government policy by identifying several factors that influenced to attract foreign investment to oil and gas sector and examines significant challenges that still remain for further development of the country's oil industry.

12/01116 Do emerging markets matter in the world oil pricing system? Evidence of imported crude by China and India

Li, H. and Lin, S. X. *Energy Policy*, 2011, 39, (8), 4624–4630.

This paper provides empirical evidence on the changing structure of world oil price system by identifying an additional driver-emerging market factor. China and India were chosen as representative of emerging markets to examine if the quantity of crude oil imported by China and India is significant in the existing oil pricing system. The data start from January 2002 and end in March 2010, which includes the oil shock of 2007–2008. The authors use a cointegration and error correction model framework developed earlier in the analysis. The results indicate that demand from emerging markets has become a significant factor in the world oil pricing system since 2003. This result is significant as it lends empirical support to the widely held conjecture that the oil shock of 2007–2008 is a demand-led shock. The result also has significant policy implications that go beyond the oil shock. The emerging market factor is there to stay and reflects the changing power between emerging and developed economies in the world economic system as a result of decades of fast economic development in the former. It will certainly influence policy issues related to oil and beyond.

12/01117 Energy return on (energy) invested (EROI), oil prices, and energy transitions

Heun, M. K. and de Wit, M. *Energy Policy*, 2012, 40, 147–158.

Very little work has been done so far to model, test, and understand the relationship between oil prices and energy return on energy invested (EROI) over time. This paper investigates whether a declining EROI is associated with an increasing oil price and speculates on the implications of these results on oil policy. A model of the relationship between EROI and oil market prices was developed using basic economic and physical assumptions and non-linear least-squares regression models to correlate oil production price with EROI using available data from 1954 to 1996. The model accurately reflects historical oil prices (1954–1996), and it correlates well with historical oil prices (1997–2010) if a linear extrapolation of EROI decline is assumed. As EROI declines below 10, highly non-linear oil price movements are observed. Increasing physical oil scarcity is already providing market signals that would stimulate a transition away from oil toward alternative energy sources. But, price signals of physical oil scarcity are not sufficient to guarantee smooth transitions to alternative fuel sources, especially when there is insufficient oil extraction technology development, a declining mark-up ratio, a non-linear EROI–cost of production relationship, and a non-linear EROI–price relationship.

12/01118 Estimating the demand for gasoline in developing countries: Senegal

Sene, S. O. *Energy Economics*, 2012, 34, (1), 189–194.

This paper estimates the aggregate demand for gasoline in Senegal from 1970 to 2008. The long-term and short-term elasticities of demand with respect to gasoline prices and income are of paramount interest in this study. In Senegal, rising food prices, unemployment and shortage of electric supply are always associated with the spiking cost of world oil prices. To understand the external shocks of world oil price and demand for gasoline in Senegal, this study tested a log linear model against the linear model of the demand-for-oil function with lagged dependent variables as an explanatory variable. Here, the linear specification of the demand for oil is rejected in this study in favour of the log linear. The natural log transformation is typical when using high frequency data and significantly reduces skewness and kurtosis. Generally in this study, I found that short run elasticity is smaller than long-run elasticity and gasoline demand is inelastic with respect to both price and income for both the short and long runs in Senegal.

12/01119 Forecasting the differences between various commercial oil prices in the Persian Gulf region by neural network

Movagharnejad, K. *et al. Energy*, 2011, 36, (7), 3979–3984.

The differences between the prices of different commercial oils of the Persian Gulf region are investigated. The prices of seven different crude oils from Iran, Kuwait, Saudi Arabia, Oman, Abu Dhabi and Dubai were compared with the benchmark light oil of Saudi Arabia over the period January 2000–April 2010. A neural network is introduced to forecast the price of any commercial oil in these crude oils, provided that the price of the benchmark light oil of Saudi Arabia is already known or is predicted by another forecasting method. The designed neural network is able to predict the differences in the oil prices with an average error of 8.82% for testing and 7.24% for training data. It is claimed that the present method can promote the forecasting power of existing models to predict the price of any commercial oil instead of an average or benchmark value.

12/01120 Inventories and upstream gasoline price dynamics

Kuper, G. H. *Energy Economics*, 2012, 34, (1), 208–214.

This paper sheds new light on the asymmetric dynamics in upstream US gasoline prices. The model is based on Pindyck's inventory model of commodity price dynamics. The authors show that asymmetry in gasoline price dynamics is caused by changes in the net marginal convenience yield: higher costs of marketing and storage lead to rising gasoline prices, whereas a drop in these costs lowers gasoline prices. The former effect is stronger. This indicates asymmetric dynamics. The authors also analyse the asymmetry across the sample by analysing recursive and rolling regressions.

12/01121 Modeling the implications of expanded US shale gas production

Medlock III, K. B. *Energy Strategy Reviews*, 2012, 1, (1), 33–41.

Conventional thinking just 10 years ago was that the USA would become a major importer of liquefied natural gas. Yet, today the discussion has shifted to one of export potential, largely driven by the rapid development of shale gas resources. This has had dramatic implications not only for the USA, but also for the rest of the world. In particular, the outlook for several gas exporting countries has been substantially altered. Namely, while the USA has certainly from an energy security standpoint, Russia, Iran, Venezuela and Qatar have seen their projected fortunes reduced. Development of shale gas has effectively increased the global elasticity of supply and could substantially reduce overall dependence on exports from these critical countries.

12/01122 Oil price, biofuels and food supply

Timilsina, G. R. *et al. Energy Policy*, 2011, 39, (12), 8098–8105.

The price of oil could play a significant role in influencing the expansion of biofuels, but this issue has yet to be fully investigated in the literature. Using a global computable general equilibrium (CGE) model, this study analyses the impact of oil price on biofuel expansion, and subsequently, on food supply. The study shows that a 65% increase in oil price in 2020 from the 2009 level would increase the global biofuel penetration to 5.4% in 2020 from 2.4% in 2009. If oil prices rise 150% from their 2009 levels by 2020, the resulting penetration of biofuels would be 9%, which is higher than that would be caused by current mandates and targets introduced in more than forty countries around the world. The study also shows that aggregate agricultural output drops due to an oil price increase, but the drop is small in major biofuel producing countries as the expansion of biofuels would partially offset the negative impacts of the oil price increase on agricultural outputs. An increase in oil price would reduce global food supply through direct impacts as well as through the diversion of food commodities and cropland towards the production of biofuels.

12/01123 The development and commercialization of solar PV technology in the oil industry

Pinkse, J. and van den Buuse, D. *Energy Policy*, 2012, 40, 11–20.

In diversifying energy supply, the transformation of the energy industry has been identified as a key challenge for a sustainable energy future. This suggests that incumbent firms in this industry have a vital role in the development and commercialization process of renewable energy technologies. This paper provides a comparative analysis of oil and gas firms' strategies regarding solar PV technology investments, a renewable energy technology that has seen explosive growth of late. The main aim is to examine the strategic approach of incumbent firms in the oil and gas industry towards the development and commercialization of solar PV technology. To investigate this, a multiple case study has been conducted within the European oil industry, focusing on the three largest oil and gas firms: BP, Royal Dutch/Shell, and Total. Findings show that oil and gas firms have difficulties with integrating solar PV technology in their supply chain. The analysis suggests that it is uncertain whether all oil and gas firms will abandon solar completely, as this depends to what extent they are able to generate profits. Nevertheless, there is currently a trend in the oil industry of leaving solar and positioning towards a 'recarbonization' of business activities.

12/01124 The effects of oil prices on inflation, interest rates and money

Wu, M.-H. and Ni, Y.-S. *Energy*, 2011, 36, (7), 4158–4164.

Recently, many studies have focused on oil price shocks to economic variables such as GDP, interest rates, inflation, and industrial production, but few studies have focused on external shocks to the possible reaction of monetary policies. Thus, this paper includes money variables in empirical models and investigates the relationships among oil prices, inflation, interest rates and money. The monetary policy might take time to be effective, so the concerns of lag-chosen issues will be vital issues from the aspect of this research. Then, different lag-chosen criteria and symmetric and asymmetric lag-lengths chosen are placed in a stressed situation in this study with regard to monetary lag concerns. It is found that the empirical results are quite robust concerning various lag-chosen criteria, symmetric and asymmetric models, and different time series models. So, it implies that monetary policies still matter after accounting for the oil prices, the energetic variable, with the above robustness concerns.

12/01125 Volatility regimes, asymmetric basis effects and forecasting performance: an empirical investigation of the WTI crude oil futures market

Chang, K.-L. *Energy Economics*, 2012, 34, (1), 294–306.

This study employs a flexible regime-switching EGARCH model with Student-*t* distributed error terms to investigate whether volatility regimes and basis affect the behaviour of crude oil futures returns, including the conditional mean, variance, skewness, kurtosis as well as the extent of heavy-tailedness. The study also examines whether volatility regimes and asymmetric basis effects can improve the forecasting accuracy. The main merit of the empirical model is that the basis effect is allowed to be asymmetric and to vary across volatility regimes. Empirical results suggest that the conditional mean and variance respond to the basis asymmetrically and non-linearly, and that the responses of transition probabilities to the basis are symmetric. Furthermore, the conditional higher moments are sensitive to the absolute value of basis, and the heavy tailed characteristic can be greatly alleviated by taking into account the asymmetric basis effects and regime switches. Finally, the regime switches and asymmetric basis effects play decisive roles in forecasting return, volatility and tail distribution.

Derived liquid fuels

12/01126 Activation of methane and carbon dioxide in a dielectric-barrier discharge-plasma reactor to produce hydrocarbons – influence of La_2O_3/γ-Al_2O_3 catalyst

Pham, M. H. *et al. Catalysis Today*, 2011, 171, (1), 67–71.

The activation of methane and carbon dioxide to produce hydrocarbons has been investigated in a dielectric barrier discharge (DBD) reactor. A high CH_4/CO_2 ratio is more selective for the production of C2 hydrocarbons, but the carbon balance is always far from 100% due to carbon deposition and formation of heavy molecules. An increase of the reaction temperature until 600 °C is more favourable for ethylene formation. The presence of glass or alumina balls in the plasma improves the stability of the plasma discharge leading to an increase of the CO_2 and CH_4 conversion. The use of the catalyst La_2O_3/γ-Al_2O_3 in the plasma zone, at 400 °C, modifies significantly the activation of carbon dioxide while it does not affect the activation of methane. This result can be attributed to the formation of surface oxycarbonate species responsible for the higher carbon monoxide selectivity.

12/01127 Analysis of flammability limits for the liquefaction process of oxygen-bearing coal-bed methane

Li, Q. Y. *et al. Applied Energy*, 2011, 88, (9), 2734–2939.

A novel liquefaction and distillation process has been proposed and designed for the typical oxygen-bearing coal-bed methane (CBM), in which the impurities of the oxygen and nitrogen components are removed in the distillation column. The flammability limit theory combining with HYSYS simulation results are employed to analyse and calculate the flammability limits and the results indicate that no flammability hazard exists in the stages of compression, liquefaction and throttling. However, flammability hazard exists at the top the distillation column because the methane mole fraction decreases to the value below the upper flammability limit (UFL). The safety measures of initially removing oxygen content from the feed gas combining with the control of the bottom flowrate (flowrate of the liquid product at column bottom) are proposed to ensure the operation safety of the liquefaction process. The results reveal that the operation safety of the whole process can be guaranteed, together with high methane recovery rate and high purity of the liquid product. The applicability of the liquefaction process has also been analysed in this paper. The simulation results can offer references for the separation of oxygen from CBM, the analysis of flammability limits and the safety measures for the whole process.

12/01128 Combustion characteristics of a charcoal slurry in a direct injection diesel engine and the impact on the injection system performance

Soloiu, V. *et al. Energy*, 2011, 36, (7), 4353–4371.

The paper presents the research results pertaining to the renewable biomass charcoal–diesel slurries and their use as alternative fuels for combustion in diesel generating plants. The utilization of charcoal slurry fuel aims to reduce diesel oil consumption and would decrease fossil greenhouse emissions into the atmosphere. The paper investigates the formulation, emulsification, sprays, combustion, injection system operation, and subsequent wear with charcoal–diesel slurries. In the research, cedar wood chips were used for the production of charcoal to be emulsified with diesel oil. The slurry's viscosity of 27 cP achieved the target (<100 cP) and gave prospects of good spray atomization and while maintaining a high calorific value. Thermal analysis studies found that cedar wood will oxidize about 75% of its original mass by 450 °C. Charcoal slurry displayed a high vaporization rate of 75% by weight at 300 °C. Engine investigations showed that the top combustion pressure at 1200 rpm and 100% load (7.8 brake mean effective pressure, bmep) was 79 bar for diesel fuel and 78 bar for the charcoal slurry fuel. From the injection and heat release history was found an ignition delay of 1.7 ms for diesel that increased to 2.1 ms for the slurry fuel. A higher net heat release for charcoal slurry was observed, up to 180 J/crank angle degrees (CAD) compared with the diesel at 145 J/CAD The maximum combustion temperature reached 2300 K for diesel and 2330 K for slurry. The heat fluxes for both fuels have similar values and trends during the entire cycle showing the good compatibility of charcoal slurry with a diesel type combustion and low soot radiation. The exhaust temperatures were about 40–50 °C higher for charcoal slurry at 19° before top dead centre (BTDC) injection timing. The engine's bsfc increased as expected due to the lower heating value of the slurry fuel. The smoke Bosch no. was lower for the slurry fuel at any load, and is believed that the oxygen from the charcoal had a beneficial effect. The measured emissions of slurry fuel were better at 13° BTDC than those of diesel fuel with the original engine settings and the remaining 6–10% oxygen content in the charcoal is thought to have a paramount role in helping the diffusion type combustion and diminishing the particulate matter formation. As the load was increased, the amount of time it took to notice a decline in engine efficiency decreased. This was due to the injector sticking open which was seen by a sharp increase in the exhaust temperature. The internal flow into the injector had the tendency to form deposits on the injector's seat that were critical to the functionality of the injector. In order to alleviate this problem, a reduced charcoal particle size together with a new injector design were produced resulting in stable engine efficiency at 50% load for a period of 90 min without injector sticking. Even with improvements, the needle's seat into the injector body showed an accelerated wear four to eight times faster than that in normal operation with diesel fuel and this cannot be sustained for long operational cycles. The investigations have proven that the new charcoal–diesel slurry can produce adequate sprays and burn with very good results in a direct injection diesel engine. The critical aspect of operation is the internal flow into the injector with the tendency to form deposits and wear in the injector.

12/01129 Converting crude glycerol to 1,3-propandiol using resting and immobilized *Klebsiella* sp. HE-2 cells

Wong, C.-L. *et al. Biochemical Engineering Journal*, 2011, 58–59, 177–183.

In this study, 1,3-propanediol (1,3-PDO) was produced from crude glycerol through the fermentation of resting and immobilized cells of a *Klebsieblla* sp. HE-2 strain isolated from a hydrogen producing anaerobic sludge collected in southern Taiwan. The *Klebsieblla* sp. HE-2 cells were first grown on a fermentation medium (FM medium). The medium was then switched to resting-cell medium (RC medium) tailored to improve the production of 1,3-PDO. Using a glycerol-amended FM medium, the soluble metabolites consisted of 1,3-PDO, 2,3-butanediol, and ethanol and byproducts (such as acetic acid and lactic acid) at a content of 18, 28, 49, and 5% (of total soluble metabolites), respectively. When the culture was transferred from the FM medium to the RC medium, the concentration of 1,3-PDO was doubled from 5 g/L to 10 g/L. Using immobilized cells of *Klebsieblla* sp. HE-2 greatly improved the operational stability and reusability of the cells, as the immobilized cells could be used for six cycles without significant activity loss. The immobilized cells were able to directly utilize non-pretreated crude glycerol obtained from a local biodiesel manufacturing plant for 1,3-PDO production with an efficiency comparable to that obtained from using pure glycerol.

12/01130 Etherification of 5-hydroxymethyl-2-furfural (HMF) with ethanol to biodiesel components using mesoporous solid acidic catalysts

Lanzafame, P. *et al. Catalysis Today*, 2011, 175, (1), 435–441.

The etherification of 5-hydroxymethyl-2-furfural (HMF) with ethanol is studied over a series of mesoporous silica catalysts (Al-MCM-41 materials with different Si/Al ratio, and zirconia or sulfated zirconia supported over SBA-15) and compared with the behaviour of H_2SO_2 and Amberlyst®15. The observed reaction products were 5-(ethoxymethyl)furan-2-carbaldehyde (EMF), 1,1-dietoxy ethane (DE) and ethyl 4-oxopentanoate (EOP). The selectivity to EMF and EOP is closely related to the presence of Lewis and/or Brønsted acidity on the catalyst, while the formation of DE is probably related to defect sites. The latter, being less reactive, catalyse the side reaction to DE only when strong Lewis and/or Brønsted acid sites are absent. Catalysts with only a strong Brønsted acidity react selectively to form EOP. When strong Lewis acid sites are present in the catalyst, e.g. by introducing ZrO_2 in SBA-15 or when extra-framework isolated Al^{3+} sites are present in the mesoporous channels, a high selectivity to EMF was observed. The results indicate that EMF, DE or EOP can be obtained selectively by direct reaction of HMF with bioethanol by tuning the acidity of the catalyst. EMF is a value biodiesel component, but the results also evidence the possibility to obtain selectively EOP in a one-step reaction, opening interesting perspectives to produce valeric biofuels by subsequent selective hydrogenation.

12/01131 Exopolysaccharide production by a genetically engineered *Enterobacter cloacae* strain for microbial enhanced oil recovery

Sun, S. *et al. Bioresource Technology*, 2011, 102, (10), 6153–6158.
Microbial enhanced oil recovery (MEOR) is a petroleum biotechnology for manipulating function and/or structure of microbial environments existing in oil reservoirs for prolonged exploitation of the largest source of energy. In this study, an *Enterobacter cloacae* which is capable of producing water-insoluble biopolymers at 37 °C and a thermophilic *Geobacillus* strain were used to construct an engineered strain for exopolysaccharide production at higher temperature. The resultant transformants, GW3–3.0, could produce exopolysaccharide up to 8.83 g l^{-1} in molasses medium at 54 °C. This elevated temperature was within the same temperature range as that for many oil reservoirs. The transformants had stable genetic phenotype which was genetically fingerprinted by RAPD analysis. Core flooding experiments were carried out to ensure effective controlled profile for the simulation of oil recovery. The results have demonstrated that this approach has a promising application potential in MEOR.

12/01132 High-rate conversion of methane to methanol by *Methylosinus trichosporium* OB3b

Duan, C. *et al. Bioresource Technology*, 2011, 102, (15), 7349–7353.
Methanol was produced from methane with a high conversion rate using a high cell density process with *Methylosinus trichosporium* OB3b in the presence of a high concentration of phosphate buffer. More than 1.1 g/L methanol accumulated in the reaction media under optimized reaction conditions (17 g dry cell/L, 400 mmol/L phosphate, and 10 mmol/L $MgCl_2$) in the presence of 20 mmol/L sodium formate. The conversion rate of methane was over 60%. About 0.95 g/L methanol was produced when the biotransformation was carried out in a membrane aerated reactor into which methane and oxygen were introduced via two separate dense silicone tubing. The results provide an efficient method and a promising process for high-rate conversion of methane to methanol.

12/01133 Hydroliquefaction of green wastes to produce fuels

Beauchet, R. *et al. Bioresource Technology*, 2011, 102, (10), 6200–6207.
The direct liquefaction of a biomass composed of a mixture of wastes (straw, wood and grass) was studied using Nickel Raney as catalyst and tetralin as a solvent. Tetralin allows to solubilize green waste from 330 °C at relatively low hydrogen pressure, and avoids the recondensation of the intermediate products. The green waste deoxygenation results mainly from a decarboxylation reaction. The addition of Raney Ni in the feed, increases the gas yield due to methane formation, without diminishing the yield in solvolysis oil. The catalyst hydrogenolyses the small molecules present in the light fraction. Moreover, it improves the quality of the oil by increasing the hydrogen transfer between the solvent and the solvolysis oil. As a consequence, the oxygen content decreases and the yield of oil soluble in hexane strongly increases. The catalyst allows to obtain straight long chain alkanes (C_{13}–C_{26}), which result from the hydrogenation of the extractives compounds of the green waste.

12/01134 Methane conversion to light olefins – how does the methyl halide route differ from the methanol to olefins (MTO) route?

Olsbye, U. *et al. Catalysis Today*, 2011, 171, (1), 211–220.
The methyl halide to hydrocarbons (MeXTH) reaction represents the second step in a potential two-step route from methane to light olefins or gasoline-range hydrocarbon mixtures. In this contribution, the methyl chloride to olefins reaction (MeXTO) was studied over a H-SAPO-34 catalyst with (Al + P)/Si = 19 by means of catalytic testing at 350–400 °C and WHSV = 11.7 h^{-1}, infrared spectroscopy and isotopic labelling experiments. Only minor degradation of the H-SAPO-34 material was observed by X-ray diffraction or infrared spectroscopy after five sequential test-regeneration cycles at 400 °C and 550 °C, respectively. Co-feed experiments using ^{13}C-methyl chloride and ^{12}C-ethene or ^{12}C-propene at 400 °C indicated that the conversion level of each compound is directly related to its proton affinity. Furthermore, under the conditions used, no inhibitive effect of the alkenes on methyl chloride conversion was observed. Transient isotopic labelling experiments suggested that hexamethyl benzene is an important reaction intermediate in alkene formation from methyl chloride. However, the isotopic labelling of effluent products during ^{13}C-methyl chloride–^{12}C-alkene co-feed experiments suggested that alkene methylation and interconversion reactions may contribute significantly to C_3^+ formation. The findings are in general agreement with similar studies of the methanol to olefins reaction over the same catalyst topology.

12/01135 Rh-catalyzed syngas conversion to ethanol: studies on the promoting effect of FeO_x

Wang, J. *et al. Catalysis Today*, 2011, 171, (1), 257–265.
Rhodium catalysts loaded on silica modified by various transition metal oxides were investigated for the conversion of syngas to ethanol. Iron oxide was found to be an efficient promoter for ethanol formation. The increase in iron content up to 5 wt% significantly increased CO conversion and ethanol selectivity. The preparation method used for introducing FeO_x was found to affect both the conversion and the selectivity significantly. The catalyst prepared by the impregnation of a FeO_x–SiO_2 composite, which was synthesized by a sol–gel technique preliminarily, with $Rh(NO_3)_3$ aqueous solution provided better ethanol formation activity than those prepared by co-impregnation and co-sol–gel methods. An ethanol selectivity of 42% was achieved at CO conversion of 12% over a 5 wt% Rh/(5 wt% FeO_x–SiO_2) catalyst prepared by this method. Larger interfaces between Rh and FeO_x species were proposed to be a crucial factor for obtaining higher ethanol selectivity. The co-existence of Rh^{3+} with Rh^0 and the size of Rh particles also played key roles in ethanol formation.

12/01136 The characteristics of organic sludge/sawdust derived fuel

Chen, W.-S. *et al. Bioresource Technology*, 2011, 102, (9), 5406–5410.
A fundamental study of the characteristics of a sludge refuse-derived fuel (RDF) and the combustion behaviours were done. The test data demonstrate good results for the development of energy recovery technology of organic sludge or waste. The ash deposit formation propensity has been based on pretreatment, temperature and the ratio of organic sludge to sawdust. The usage of organic sludge and waste as an alternative fuel is cost effective and has environmental benefits.

03 GASEOUS FUELS

Sources, properties, recovery, treatment

12/01137 CO_2 removal from natural gas by employing amine absorption and membrane technology – a technical and economical analysis

Peters, L. *et al. Chemical Engineering Journal*, 2011, 172, (2–3), 952–960.
A technical and economic analysis of gas sweetening processes for natural gas with amine absorption and membrane technology has been conducted. Amine absorption is still considered a state of the art technology for gas sweetening but membranes have shown a great potential in this area, if the flux and selectivity for CO_2 is high enough. The PVAm/PVA (polyvinyl amine and polyvinyl alcohol) membrane, developed at NTNU shows such qualities. For two different feed gas cases a simulation analysis with Aspen Hysys for amine absorption and a membrane model interfaced within Aspen Hysys was performed. Further, an economic analysis was also conducted to evaluate the total capital investment and gas processing cost for both technologies.

12/01138 Soil gas composition above gas deposits and perspective structures of the Carpathian Foredeep, SE Poland

Sechman, H. *et al. Applied Geochemistry*, 2012, 27, (1), 197–210.
In 2001, a surface geochemical survey was carried out in the Carpathian Foredeep, in the area between Jaroslaw and Radymno (south-east Poland) where multi-horizon gas deposits were discovered. These deposits accumulate microbial CH_4 with small amounts of N_2 and higher molecular weight gaseous hydrocarbons. Soil–gas composition in the hydrocarbon fields in the study area is relatively different from the original composition of natural gas occurring in the subsurface reservoir. In 449 analysed soil gas samples collected from 1.2 m depth

relatively low concentrations were found for CH_4 (median value 2.2 ppm) and its homologues (median value of total alkanes C_2–C_4 – 0.02 ppm). Alkenes were encountered in 36.3% of the analysed samples (mean value of total alkenes C_2–C_4 – 0.015 ppm) together with distinctly higher concentrations of H_2 (maximum value – 544 ppm, mean value – 42 ppm) and CO_2 (maximum value – 10.26 vol.%, mean value – 2.27 vol.%). Individual, very high concentrations of CH_4 (up to about 35 vol.%) resulted from sub-surface biochemical reactions whereas higher alkanes detected in soil gases (up to about 68 ppm) originated from deep gas accumulations. Both the H_2 and alkenes may be indirect indicators of deep hydrocarbon accumulations. Carbon dioxide may also be useful for hydrocarbon exploration, revealing increased concentrations in those sampling sites where CH_4 concentrations are strongly depleted, presumably due to bacterial oxidation. These relationships are valid only for the study area and should not be extended as a universal principle. The interpreted zones of cumulative anomalies of CH_4, higher molecular weight gaseous hydrocarbons, H_2 and CO_2 related to the results of geological and geophysical studies directly or indirectly point to the presence of undiscovered, deep gas accumulations and suggest larger sizes for known deposits. The character of the anomalies along with the relationships between the components of soil gases support the opinion that gas accumulations occur at various depths. Moreover, the results indicate that the surface geochemical pattern is significantly influenced by tectonic discontinuities.

12/01139 Using size distribution analysis to forecast natural gas resources in Asia Pacific

Aguilera, R. F. and Ripple, R. D. *Applied Energy*, 2011, 88, (12), 4607–4620.

Increasing energy consumption in Asia Pacific will largely be met by fossil fuels. Natural gas production in the region presently ranks behind that of oil and coal. However, the abundance of gas could lead to a significant gas market share increase in the energy mix. The purpose of this paper is to estimate the total endowment of conventional gas in Asia Pacific. This is carried out with a variable shape distribution model that forecasts volumes in provinces that have not been previously evaluated. The endowment is then distributed across countries to show where volumes are most likely to be found. A breakdown between offshore versus onshore resources is also estimated. The results of the analysis show there is a significant gas endowment. The estimated distribution across countries and onshore/offshore areas provides insight into the relative economics of gas production, as well as a basis for potential investment decisions. With appropriate energy policies, it may be possible to tap the vast gas potential in Asia Pacific. Considering gas may be the most abundant, inexpensive, and clean fossil fuel, the outcome would be increased energy security and a low carbon economy.

Transport, storage

12/01140 A hybrid Delphi-SWOT paradigm for oil and gas pipeline strategic planning in Caspian Sea basin

Tavana, M. *et al. Energy Policy*, 2012, 40, 345–360.

The Caspian Sea basin holds large quantities of both oil and natural gas that could help meet the increasing global demand for energy resources. Consequently, the oil and gas potential of the region has attracted the attention of the international oil and gas industry. The key to realizing the energy producing potential of the region is the development of transnational export routes to take oil and gas from the landlocked Caspian Sea basin to world markets. The evaluation and selection of alternative transnational export routes is a complex multicriteria problem with conflicting objectives. The decision-makers are required to consider a vast amount of information concerning internal strengths and weaknesses of the alternative routes as well as external opportunities and threats to them. This paper presents a hybrid model that combines strength, weakness, opportunity and threat analysis with the Delphi method.

12/01141 A review of physical modelling and numerical simulation of long-term geological storage of CO_2

Jiang, X. *Applied Energy*, 2011, 88, (11), 3557–3566.

Numerical simulations are essential to the understanding of the long-term geological storage of CO_2. Physical modelling of geological storage of CO_2 has been based on Darcy's law, together with the equations of conservation of mass and energy. Modelling and simulations can be used to predict where CO_2 is likely to flow, to interpret the volume and spatial distribution of CO_2 under storage conditions, and to optimise injection operations. The state of the art of physical modelling and numerical simulation of CO_2 dispersion is briefly reviewed in this paper, which calls for more accurate and more efficient modelling approaches. A systematic evaluation of the numerical methods used and a comparison between the streamline based methods and the grid based methods would be valuable. Multiscale modelling may prove to be of great value in predicting the long-term geological storage of CO_2, while highly accurate numerical methods such as high-order schemes may be employed in numerical simulations of CO_2 dispersion for local transport calculations.

12/01142 A rigorous mechanistic model for predicting gas hydrate formation kinetics: the case of CO_2 recovery and sequestration

ZareNezhad, B. *et al. Energy Conversion and Management*, 2012, 53, (1), 332–336.

A rigorous mechanistic model for predicting gas hydrate formation crystallization kinetics is presented and the special case of CO_2 gas hydrate formation regarding CO_2 recovery and sequestration processes has been investigated by using the proposed model. A physical model for prediction of secondary nucleation rate is proposed for the first time and the formation rates of secondary nuclei by crystal–crystal collisions and crystal–impeller collisions are formulated. The objective functions for simultaneous determination of nucleation and growth kinetics are presented and a theoretical framework for predicting the dynamic behaviour of gas hydrate formation is presented. Predicted time variations of CO_2 content, total number and surface area of produced hydrate crystals are in good agreement with the available experimental data. The proposed approach can have considerable application for design of gas hydrate converters regarding energy storage and CO_2 recovery processes.

12/01143 A second life for natural gas demand in Europe?

Christie, E. H. *Energy Strategy Reviews*, 2012, 1, (1), 62–65.

The European Union's (EU) natural gas balance is projected to deteriorate rapidly over the next couple of decades due to strongly decreasing domestic production. According to the IEA's World Energy Outlook 2011, the EU's production is expected to fall from 216 bcm in 2008 to 89 bcm in 2035. Different energy models come to different conclusions concerning the evolution of demand, but none of them project demand falling fast enough to offset the fall in production before at least 2030. In this paper the goal is to focus more closely on selected strategy drivers and on specific market segments in order to shed light on what may drive EU gas demand in future. Brief sections follow, addressing power generation costs and the price of carbon; recent political decisions to move away from nuclear power; and natural gas in the transport sector.

12/01144 Carbon sequestration and annual increase of carbon stock in a mangrove forest

Ray, R. *et al. Atmospheric Environment*, 2011, 45, (28), 5016–5024.

Carbon stock is lower in the tropical mangrove forest than in the terrestrial tropical forest and its annual increase exhibits faster turnover than the tropical forest. Variable for above ground biomass are in decreasing order of importance, breast height diameter (d), height (H) and wood density (ρ). The above ground biomass (AGB) and live below ground biomass (LBGB) held different biomass ($39.93 \pm 14.05\,\mathrm{t\,C\,ha^{-1}}$ versus $9.61 \pm 3.37\,\mathrm{t\,C\,ha^{-1}}$). Carbon accrual to live biomass (4.71–$6.54\,\mathrm{Mg\,C\,ha^{-1}\,a^{-1}}$) is more than offset by losses from litter fall ($4.85\,\mathrm{Mg\,C\,ha^{-1}\,a^{-1}}$), and carbon sequestration differs significantly between live biomass ($1.69\,\mathrm{Mg\,C\,ha^{-1}\,a^{-1}}$) and sediment ($0.012\,\mathrm{Mg\,C\,ha^{-1}\,a^{-1}}$). Growth specific analyses of taxon density suggest that changes in resource availability and environmental constrains could be the cause of the annual increase in carbon stocks in the Sundarbans mangrove forest in contrast to the disturbance–recovery hypotheses.

12/01145 Suitability analysis of lumped-capacitance formulations for adsorbed gas storage

Jurumenha, D. S. and Sphaier, L. A. *Applied Thermal Engineering*, 2011, 31, (14–15), 2458–2463.

Mathematical modelling and numerical solutions can be of great assistance for simulating heat transfer in adsorbed gas (AG) storage operations, leading to better thermal designs of AG reservoirs. Nevertheless, the complexities associated with modelling heat and mass transfer that occur within adsorbed gas processes can lead to formulations that require a great computational effort. In this paper, a complex multidimensional formulation is shown to be reducible to a simple lumped-capacitance model via an averaging procedure. Naturally, this simpler formulation cannot represent accurately a significant number of cases. Hence, a comparison between the simpler lumped formulation with one that considers spatial dependence is provided for estimating ranges of applicability for the simpler form. The results indicate that the Biot number alone cannot be used as a criteria for determining whether a lumped-capacitance model can be accurately employed.

12/01146 The cost of pipelining climate change mitigation: an overview of the economics of CH_4, CO_2 and H_2 transportation

van der Zwaan, B. C. C. *et al. Applied Energy*, 2011, 88, (11), 3821–3831.

Gases like CH_4, CO_2 and H_2 may play a key role in establishing a sustainable energy system: CH_4 is the least carbon-intensive fossil energy resource; CO_2 capture and storage can significantly reduce the climate footprint of especially fossil-based electricity generation; and the use of H_2 as energy carrier could enable carbon-free automotive transportation. Yet the construction of large pipeline infrastructures usually constitutes a major and time-consuming undertaking, because of safety and environmental issues, legal and (geo)political siting arguments, technically un-trivial installation processes, and/or high investment cost requirements. In this article the focus is on the latter and present an overview of both the total costs and cost components of the distribution of these three gases via pipelines. Possible intricacies and external factors that strongly influence these costs, like the choice of location and terrain, are also included in the analysis. The distribution cost breakdown estimates are based on transportation data for CH_4, which are adjusted for CO_2 and H_2 in order to account for the specific additional characteristics of these two gases. The overall trend is that pipeline construction is no longer subject to significant cost reductions. For the purpose of designing energy and climate policy it is therefore known, in principle with reasonable certainty, what the minimum distribution cost components of future energy systems are that rely on pipelining these gases. The reasons why limited learning-by-doing is observed are described and why negligible construction cost reductions for future CH_4, CO_2 and H_2 pipeline projects can be expected are explained. Cost data of individual pipeline projects may strongly deviate from the global average because of national or regional effects related to the type of terrain, but also to varying costs of labour and fluctuating market prices of components like steel.

Economics, business, marketing, policy

12/01147 A conditionally heteroskedastic model with time-varying coefficients for daily gas spot prices

Regnard, N. and Zakoïan, J.-M. *Energy Economics*, 2011, 33, (6), 1240–1251.

This paper examines the relationship between gas spot prices at the Zeebrugge market, one-month ahead Brent prices and temperatures over the period 2000–2005. A cointegration analysis is carried out and it is discovered that a cointegration relationship exists between the three series. To take into account the influence of temperature on the gas volatility, a GARCH(1,1) model with temperature-dependent coefficients is considered. Stability and estimation properties are discussed. An empirical finding is the existence of distinct volatility regimes for the volatility of gas prices, depending on the temperature level.

12/01148 A neuro-fuzzy-stochastic frontier analysis approach for long-term natural gas consumption forecasting and behavior analysis: the cases of Bahrain, Saudi Arabia, Syria, and UAE

Azadeh, A. *et al. Applied Energy*, 2011, 88, (11), 3850–3859.

This paper presents an adaptive network-based fuzzy inference system-stochastic frontier analysis (ANFIS-SFA) approach for long-term natural gas (NG) consumption prediction and analysis of the behaviour of NG consumption. The proposed models consist of input variables of gross domestic product (GDP) and population (POP). Six distinct models based on different inputs are defined. All of trained ANFIS are then compared with respect to mean absolute percentage error (MAPE). To meet the best performance of the intelligent based approaches, data are pre-processed (scaled) and finally the outputs are post-processed (returned to its original scale). To show the applicability and superiority of the integrated ANFIS-SFA approach, gas consumption in four Middle Eastern countries, i.e. Bahrain, Saudi Arabia, Syria, and United Arab Emirates, is forecast and analysed based on the data of the time period 1980–2007. With the aid of autoregressive model, GDP and population are projected for the period 2008–2015. These projected data are used as the input of ANFIS model to predict the gas consumption in the selected countries for 2008–2015. SFA is then used to examine the behaviour of gas consumption in the past and also to make insights for the forthcoming years. The ANFIS-SFA approach is capable of dealing with complexity, uncertainty, and randomness as well as several other unique features discussed in this paper.

12/01149 An evaluation of alternative scenarios for the Gazprom monopoly of Russian gas exports

Tsygankova, M. *Energy Economics*, 2012, 34, (1), 153–161.

In June 2006, Russian federal law legalized the exclusive right of Gazprom to export natural gas to Europe, and thus thwarted efforts by the European Union to bring competition to the Russian gas industry. An understanding of the motivation of the Russian government to support this export monopoly is important if Europe wishes to reduce its dependence on Gazprom. The principal aim of this paper is to contribute to a better understanding of this important question. The analysis employs a theoretical model and several numerical simulations of an alternative organization used for gas exports, where independent gas producers in Russia are permitted to export gas to Europe. The authors evaluate the effects of this alternative organization on consumer surplus, industry profits, and Russian welfare. The results demonstrate that while export by independent producers reduces Gazprom's export profits, it may also increase the total domestic and export profits earned by the Russian gas industry. However, the results also suggest that Russian gas consumers will not benefit if independent gas producers are able to supply both the domestic and international markets.

12/01150 Cartelization in gas markets: studying the potential for a 'gas OPEC'

Gabriel, S. A. *et al. Energy Economics*, 2012, 34, (1), 137–152.

Natural gas is increasingly important as a fuel for electric power generation as well as other uses due to its environmental advantage over other fossil fuels. Using the world gas model, a large-scale energy equilibrium system based on a complementarity formulation, this paper analyses possible future gas cartels and their effects on gas markets in a number of regions across the world. In addition, scenarios related to lower transport costs and decreased unconventional gas supply in the USA are considered.

12/01151 Market-based congestion management in electric power systems with increased share of natural gas dependent power plants

Pantoš, M. *Energy*, 2011, 36, (7), 4244–4255.

The paper addresses market-based congestion management (MBCM) in electric power systems taking into account the constraints of the electric power system (EPS) and the natural gas system (NGS). The proposed method is based on the countertrade methodology, where the system operator performs minimum-cost redispatching according to bids from generators and loads. The EPS is presented by the DC model for power flow calculation, which uses power transfer distribution factors (PTDFs) to describe the relation between generators/loads and line-power flows. The proposed solution applies the Benders decomposition method to decouple the problem into a master problem and subproblem. The master problem includes the bid-based redispatching for congestion relief and the EPS feasibility check. The subproblem checks the NGS operation feasibility when gas-fired generating units are redispatched in the master problem. Any NGS violations from the subproblem are incorporated into the master problem as power constraints for the next iteration of congestion management. The master problem is solved by linear programming. The NGS is presented in a non-linear model and its feasibility check is performed using successive linear programming. Case studies illustrate the applicability of the proposed congestion management method on simple test models of the EPS and the NGS.

12/01152 Reducing the greenhouse gas footprint of shale gas

Wang, J. *et al. Energy Policy*, 2011, 39, (12), 8196–8199.

Shale gas is viewed by many as a global energy game-changer. However, serious concerns exist that shale gas generates more greenhouse gas (GHG) emissions than does coal. In this work the related published data are reviewed and a reassessment is made. It is shown that the GHG effect of shale gas is less than that of coal over long term if the higher power generation efficiency of shale gas is taken into account. In short term, the GHG effect of shale gas can be lowered to the level of that of coal if methane emissions are kept low using existing technologies. Further reducing the GHG effect of shale gas by storing CO_2 in depleted shale gas reservoirs is also discussed, with the conclusion that more CO_2 than the equivalent CO_2 emitted by the extracted shale gas could be stored in the reservoirs at significantly reduced cost.

12/01153 Stochastic analysis of natural gas consumption in residential and commercial buildings

Tavakoli, E. and Montazerin, N. *Energy and Buildings*, 2011, 43, (9), 2289–2297.

Consumer consumption characteristic is an important asset for safe design and management of gas distribution networks. Different characteristics of natural gas consumption in residential and commercial buildings are studied from statistical and stochastic points of view.

The technique is applied during 2008 and 2009 to a densely populated district in Tehran, Iran, with relatively large number of buildings (67,655 residential and 13,286 commercial buildings). There are different trends in the histograms of gas consumption, but there is a general trend in diagrams of probability index (the probability of gas consumption exceeding a specific value) and their regressions. The most frequent amount of gas consumption for all 45-day periods is 100 m^3 as compared with the annual average of 320 m^3 for residential buildings. The latter reduces to 80 m^3 for the averaged periodic consumption per unit in a building. Also it seems that the most frequent amount of periodic gas consumption of residential buildings is about 31% of their respective annual average during the warm months of the year, and 150% during the cold months. Periodic consumptions less than 1500 m^3 and average consumptions less than 1400 m^3 are more probable in residential buildings, which are larger than that of commercial ones, but this trend reverses at higher consumption values. If actual consumption is normalized by the average consumption, the number of units in the building or the floor area, the probability index of commercial buildings is generally higher than residential ones. The binomial distribution is analytically used to predict the probability of average gas consumption exceeding 320 and 2000 m^3 in two example cases of 500 and 1000 buildings.

Derived gaseous fuels

12/01154 Catalytic syngas production from greenhouse gasses: performance comparison of Ru-Al_2O_3 and Rh-CeO_2 catalysts

Djinović, P. *et al. Chemical Engineering and Processing: Process Intensification*, 2011, 50, (10), 1054–1062.

In this work, 3% Ru-Al_2O_3 and 2% Rh-CeO_2 catalysts were synthesized and tested for CH_4–CO_2 reforming activity using either CO_2-rich or CO_2-lean model biogas feed. Low carbon deposition was observed on both catalysts, which negligibly influenced catalytic activity. Catalyst deactivation during temperature programmed reaction was observed only with Ru-Al_2O_3, which was caused by metallic cluster sintering. Both catalysts exhibited good stability during the 70 h exposure to undiluted equimolar CH_4/CO_2 gas stream at 750 °C. By varying residence time in the reactor during CH_4–CO_2 reforming, very similar quantities of H_2 were consumed for water formation. Reverse water-gas shift (RWGS) reaction occurred to a very similar extent either with low or high WHSV values over both catalysts, revealing that product gas mixture contained near RWGS equilibrium composition, confirming the dominance of WGS reaction and showing that shortening the contact time would actually decrease the H_2/CO ratio in the syngas produced by CH_4–CO_2 reforming, as long as RWGS is quasi equilibrated. H_2/CO molar ratio in the produced syngas can be increased either by operating at higher temperatures, or by using a feed stream with CH_4/CO_2 ratio well above 1.

12/01155 Catalytic tar removal from bio syngas – catalyst development and kinetic studies

Schmidt, S. *et al. Catalysis Today*, 2011, 175, (1), 442–449.

The gasification of biomass can result in the formation of considerable amounts of tar in the crude gas. These impurities must be removed before further processing via Fischer–Tropsch or methanol synthesis. In terms of energy efficiency across the whole process, catalytic hot-gas-cleaning is a promising method. The operating temperature range from 450 to 700 °C results from the outlet temperature of the gasification process and the working temperature of the following synthesis steps. By means of selective, oxidative tar removal on Mo/V/W-mixed oxide catalysts tar compounds can be removed systematically, without converting the synthesis gas components hydrogen and carbon monoxide [0010] and [0015]. Therefore, stationary and transient kinetic experiments were performed with naphthalene as tar model compound on Mo/V/W-catalysts. In the temperature range of interest Mo/V/W-mixed oxides show the required performance. That way the total conversion of 2500 ppm naphthalene with an oxygen-feed of 3% ($L L^{-1}$) is already obtained at 425 °C. At the same time no conversion of CO and H_2, and, therefore no disturbance of the synthesis gas yield takes place. Therefore, the selective oxidation of the tar ingredients in crude synthesis gas on mixed oxide catalysts is a promising alternative for the tar removal in the required temperature range.

12/01156 Characterisation, kinetics and modelling of gasification of poultry manure and litter: an overview

Font-Palma, C. *et al. Energy Conversion and Management*, 2012, 53, (1), 92–98.

Environmental implications of the disposal of waste from the poultry industry have created the need for proper waste management. As a result, poultry litter has been proposed as a potential fuel candidate for thermal conversion technologies since it is an available source. This review discusses the recent advances in the physical and chemical characterization of poultry litter. The focus of this review is on gasification for energy generation and current commercial combustion facilities. Significant advances have been made in the pyrolysis, gasification and combustion investigations with the aim to determine their kinetics. These results are important for modelling work and critical issues for the simulation of poultry litter gasification are discussed.

12/01157 Characterization of PM_{10} source profiles for fugitive dust in Fushun – a city famous for coal

Kong, S. *et al. Atmospheric Environment*, 2011, 45, (30), 5351–5365.

A total of 120 fugitive dust samples were collected to acquire chemical source profiles of PM_{10} in Fushun including 27 soil dust samples, 32 road dust samples, 19 construction dust samples, 13 coal storage pile samples, two cement production samples, 13 coal-fired power plant fly ash samples, five fly ash samples from iron smelt plant and nine samples from industrial raw material and production piles. The samples were classified as 20 subtypes. The dust samples were dried, sieved, resuspended and sampled through a PM_{10} inlet onto filters, and then chemically analysed. Inductively coupled plasma-atomic emission spectrometry, ion chromatograph and thermal/optical reflectance methods were adopted for analysing 20 elements including Na, Mg, Al, Si, S, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Cd, Pb and Hg and nine ions including Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, F^-, Cl^-, NO_3^- and SO_4^{2-} as well as OC and EC, respectively. The chemical compositions were compared for 20 subtypes. Si and Ca were the most abundant elements in all the fugitive dust profiles. Enrichment factors of elements in fly ashes compared to raw coal were calculated with Fe as reference element. The highest enriched elements were Ni, Cu, Zn and Pb. Significant difference existed among PM_{10} profiles with the coefficient of divergence values ranging from 0.28 to 0.78. Profiles were compared with others. Si exhibited lower content in this study for soil and road dust while EC and Cr showed much higher content compared to others indicating the influence of coal mining and industries activities in Fushun. This was validated by source signatures analysis which indicated almost all the fugitive dust were relative to coal and may also be influenced by metallurgy. The ratios of Mn/V, V/Ni, Zn/Pb and Zn/Cd were calculated for source identification. Elemental ratios may vary widely even for the same source types with different processing courses. Chemical profiles of fugitive dust should be established based on characteristic sources for a specific region and updated timely.

12/01158 Comparisons of the hydrogen-rich syngas compositions from wet rice husk slurry steam reforming reactions using different catalysts

Kuo, H. P. *et al. Biomass and Bioenergy*, 2011, 35, (7), 3025–3031.

Rice husk slurry is pumped into a packed reactor and the products from the steam reforming reactions using different catalysts are studied. The steam/biomass weight ratio of such a system is between 3.47 and 5.25. The solids, liquid and gaseous products are a mass fraction of 2.8–4.1%, a mass fraction of 92.4–93.0% and a mass fraction of 3.5–4.7%, respectively. The hydrogen concentration in the gaseous product is approximate a volume fraction of 41% using the Al_2O_3 catalyst of a CuO mass fraction of 13%, a volume fraction of 38% using the Al_2O_3 catalyst of a Ni mass fraction of 13%, a volume fraction of 31% using the Al_2O_3 catalyst of a ZnO mass fraction of 13%, and a volume fraction of 20% using the Al_2O_3 catalyst at the reactor temperature of 800 °C. In the reactor temperature range studied (350–800 °C), the hydrogen concentration in the product stream increases monotonically with the increasing of the reactor temperature and the steam/carbon molar ratio. The value of dry gas LHV is between 9.4 $MJ\,m^{-3}$ and 12 $MJ\,m^{-3}$ at the reaction temperature of 600–800 °C. Considering the simple catalyst used in current study, the syngas of a hydrogen volume fraction of approximate 40% is obtained by pumping the biomass slurry to carry out the catalytic steam reforming reaction.

12/01159 Effect of temperature, pH and buffer presence on ethanol production from synthesis gas by *Clostridium ragsdalei*

Kundiyana, D. K. *et al. Bioresource Technology*, 2011, 102, (10), 5794–5799.

Fermentation pH, incubation temperature, and presence or absence of media buffer can alter the activity of microorganisms. For instance, carbon monoxide and hydrogen components of syngas show decreased solubility with increasing temperature, *Clostridium* species preferentially switch from acetogenesis to solventogenesis phase at pH below 5.0, and morpholinoethanesulfonic acid (MES) added as media buffer has been shown to increase lag time for ethanol production. The objective of the present study was to determine the effects of temperature, pH and MES buffer on ethanol production by *Clostridium ragsdalei*. This study showed syngas fermentation using *Cl. ragsdalei* at 32 °C with media without buffer was associated with higher ethanol concentration and reduced lag time in switching to solventogenesis. Temperature above 40 °C and pH below 5.0 were outside the optimal range for growth and metabolism of the bacteria.

12/01160 Exergy analysis of biomass-to-synthetic natural gas (SNG) process via indirect gasification of various biomass feedstock

Vitasari, C. R. *et al. Energy*, 2011, 36, (6), 3825–3837.

This paper presents an exergy analysis of SNG production via indirect gasification of various biomass feedstock, including virgin (woody) biomass as well as waste biomass (municipal solid waste and sludge). In indirect gasification heat needed for endothermic gasification reactions is produced by burning char in a separate combustion section of the gasifier and subsequently the heat is transferred to the gasification section. The advantages of indirect gasification are no syngas dilution with nitrogen and no external heat source required. The production process involves several process units, including biomass gasification, syngas cooler, cleaning and compression, methanation reactors and SNG conditioning. The process is simulated with a computer model using the flow-sheeting program Aspen Plus. The exergy analysis is performed for various operating conditions such as gasifier pressure, methanation pressure and temperature. The largest internal exergy losses occur in the gasifier followed by methanation and SNG conditioning. It is shown that exergetic efficiency of biomass-to-SNG process for woody biomass is higher than that for waste biomass. The exergetic efficiency for all biomass feedstock increases with gasification pressure, whereas the effects of methanation pressure and temperature are opposite for treated wood and waste biomass.

12/01161 Experimental and theoretical study of the adsorption of pure molecules and binary systems containing methane, carbon monoxide, carbon dioxide and nitrogen. Application to the syngas generation

Heymans, N. *et al. Chemical Engineering Science*, 2011, 66, (17), 3850–3858.

This study takes place in the context of the use of a synthesis gas in gas-to-liquid process, liquid hydrocarbon production by conversion based on Fischer–Tropsch synthesis. The aim is the process improvement by a selective recycling of the tail gas. So, pure component isotherms were measured for four gases (CO_2, CH_4, CO, N_2) of the tail gas until 2000 kPa and binary mixture (CO_2–CH_4; CO_2–N_2; CH_4–N_2) equilibria at 303.15 K and 400 and 950 kPa onto a ZSM-5 zeolite. The binary mixture equilibria were also predicted by the ideal adsorbed solution theory (IAST) and the vacancy solution model (VSM, Flory–Huggins and Wilson forms) and very good results were obtained. So not only binary mixture equilibria but also ternary and quaternary mixture adsorption can be predicted. With these data (experimental and simulated), it can be concluded that CO_2 is the most adsorbed component while N_2 is the least. These two components can be separated from CH_4 and CO which are sent in the synthesis gas production step.

12/01162 Hydrogen-rich gas production from ethanol steam reforming over Ni/Ga/Mg/Zeolite Y catalysts at mild temperature

Kwak, B. S. *et al. Applied Energy*, 2011, 88, (12), 4366–4375.

In order to reduce the coke formation over a conventional Ni/γ-Al_2O_4 catalyst and increase the activity at low temperature, an impregnation approach was used to synthesize MgO (30.0 wt%)/Zeolite Y catalysts loaded with bimetallic Ni(10.0 wt%)/Ga(10.0–30.0 wt%) and study the steam-reforming reactions of ethanol. The Ga-loaded catalyst impregnated between the Ni and Mg components exhibits significantly higher reforming reactivity compared to the conventional Ni/Mg/Zeolite Y catalyst. The main products from steam reforming over the Ni/Ga/Mg/Zeolite Y catalyst are only H_2 and CH_4 at above 550 °C, and the catalytic performances differ according to the amount of Ga. The H_2 production and ethanol conversion are maximized at 87% and 100%, respectively, over Ni(10)/Ga(30)/Mg(30)/Zeolite Y at 700 °C for 1 h at $CH_3CH_2OH{:}H_2O = 1{:}3$ and a gas hourly space velocity (GHSV) of 6740 h^{-1}, and the high performance is maintained for up to 59 h.

12/01163 Methane yield of oat husks

Kusch, S. *et al. Biomass and Bioenergy*, 2011, 35, (7), 2627–2633.

The biogas yield of solid manure from dairy cattle depends on its quality and the proportion of excreta and organic litter material contained within. The biogas yield of both faeces and straw is available in literature. Straw is a common litter material of mixed farms. However, straw is scarcely available on dairy farms. Oat husks are appropriate to replace or supplement straw for use as litter material. In this study, the actual methane yield and the total methane potential of oat husks were determined. Based on an optimized test with ground oat husks, the total methane potential resulted from regression and extrapolation of the experimental data. The total methane potential was determined with 242 L_N $CH_4\,kg^{-1}$ VS added. Additionally, the actual methane yield over retention time at a digestion temperature of 37 °C was determined, using untreated oat husks. For 42 days of retention, the methane yield was 202 L_N $CH_4\,kg^{-1}$ VS added at 52% CH_4 content. Results indicate that the methane yield of oat husks reaches the same level as that of straw. The total methane potential is not higher, but digestion of oat husks may proceed faster. Verification of the laboratory results on-farm revealed that the contribution of oat husks to overall methane production of a prototype biogas plant for solid manure might reach up to 80%.

12/01164 Optimization of tri-reformer reactor to produce synthesis gas for methanol production using differential evolution (DE) method

Arab Aboosadi, Z. *et al. Applied Energy*, 2011, 88, (8), 2691–2701.

This paper presents a study on optimization of a fixed bed tri-reformer reactor (TR). This reactor has been used instead of conventional steam reformer (CSR) and auto-thermal reformer (CAR). A theoretical investigation has been performed in order to evaluate the optimal operating conditions and enhancement of methane conversion, hydrogen production and desired H_2/CO ratio as a synthesis gas for methanol production. A mathematical heterogeneous model has been used to simulate the reactor. The process performance under steady state conditions was analysed with respect to key operational parameters (inlet temperature, O_2/CH_4, CO_2/CH_4 and steam/CH_4 ratios). The influence of these parameters on gas temperature, methane conversion, hydrogen production and H_2/CO ratio was investigated. Model validation was carried out by comparison of the reforming model results with industrial data of CSR. Differential evolution (DE) method was applied as a powerful method for optimization. Optimum feed temperature and reactant ratios (CH_4/CO_2/H_2O/O_2) are 1100 K and 1/1.3/2.46/0.47 respectively. The optimized TR has enhanced methane conversion by 3.8% relative to industrial reformers in a single reactor. Methane conversion, hydrogen yield and H_2/CO ratio in optimized TR are 97.9%, 1.84 and 1.7 respectively. The optimization results of tri-reformer were compared with the corresponding predictions from process simulation software operated at the same feed conditions.

12/01165 Thermodynamic analysis of hydrogen rich synthetic gas generation from fluidized bed gasification of rice husk

Loha, C. *et al. Energy*, 2011, 36, (7), 4063–4071.

In the present work, the generation of hydrogen-rich synthetic gas from fluidized bed steam gasification of rice husk has been studied. An equilibrium model based on equilibrium constant and material balance has been developed to predict the gas compositions. The equilibrium gas compositions are compared with the experimental data of the present group as well as of available literature. The energy and exergy analysis of the process have been carried out by varying steam to biomass ratio (ψ) within the range between 0.1–1.5 and gasification temperature from 600 °C to 900 °C. It is observed that both the energy and exergy efficiencies are maximum at the CBP (carbon boundary point) though the hydrogen production increases beyond the CBP. The HHV (higher heating value) and the external energy input both continuously increase with ψ. However, the hydrogen production initially increases with increase in temperature up to 800 °C and then becomes nearly asymptotic. The HHV decreases rapidly with increase in temperature and energy input increases. Therefore, gasification in lower temperature region is observed to be economical in terms of a trade-off between external energy input and HHV of the product gas.

LNG

12/01166 An efficient multi-stage Brayton–JT cycle for liquefaction of natural gas

Chang, H.-M. *et al. Cryogenics*, 2011, 51, (6), 278–286.

Combined multi-stage Brayton–JT refrigeration cycles are investigated as a governmental effort in Korea to develop an original liquefaction process of natural gas in accordance with recent demand of higher efficiency and larger capacity. Based upon thermodynamic optimization theory, a combined refrigeration system is proposed with nitrogen (N_2) Brayton cycle, ethylene (C2) JT cycle, and propane (C3) JT cycles, which are used for cooling the feed gas in a series of heat exchangers. Since no mixed refrigerants are used, this system is simple in operation and robust in reliability. A complete cycle design is presented to confirm its feasibility and estimate the liquefaction performance. It is expected that the proposed N2–C2–C3 cycle could have a reasonably high efficiency and the potential of great liquefaction capacity. Next steps are underway for patent application and practical process development.

12/01167 Comparative evaluation of LNG-based cogeneration systems using advanced exergetic analysis

Morosuk, T. and Tsatsaronis, G. *Energy*, 2011, 36, (6), 3771–3778.
During the past two decades the total cost of LNG technology has decreased significantly due to improvements of the liquefaction process. However, the regasification system has not been considerably improved. It is known that for the regasification process about 1.5% of LNG is used. Two novel, gas-turbine-based concepts for combining LNG regasification with the generation of electricity are discussed in this paper. These concepts have relatively low investment costs and high efficiencies. An advanced exergetic analysis is applied to one of these attractive LNG-based cogeneration systems to identify the potential for improvement and the interactions among components. In an advanced exergetic analysis, the exergy destruction within each component is split into unavoidable/avoidable and endogenous/exogenous parts. The advantages of this analysis over a conventional one are demonstrated. Some new developments in the advanced exergetic analysis and options for improving the concepts are also presented.

12/01168 Liquefied natural gas flow in the insulation wall of a cargo containment system and its evaporation

Lee, H. B. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2605–2615.
A computational method was developed for temperature prediction in the insulation wall of a cargo containment system on ships carrying cryogenic fluids. A model problem was set up for complicated physical phenomena, such as multi-phase flow, multiple gas species, flow in a porous medium, and conjugate heat transfer. Specially designed codes were developed and hooked up with a Navier–Stokes equations solver to take care of the material properties of LNG and NG, such as the additional resistance in a porous medium, the evaporation mechanism, i.e. phase change, and mass transfer. The developed method was verified by examining the overall multi-phase flow behaviour and temperature distribution in the physical domain of interest. The predicted solutions were in good agreement with the experimental data. The computational method can be adopted for use to many different structures, materials, and conditions and should be useful for the design of new LNG insulation wall systems.

12/01169 LNG: an eco-friendly cryogenic fuel for sustainable development

Kumar, S. *et al. Applied Energy*, 2011, 88, (12), 4264–4273.
As the demand of natural gas has sharply increased in the last two decades at the global level, the transportation of natural gas from different parts (gas producing to the consuming areas) of the world has become more significant. Liquefaction of natural gas provides a safer and economical alternative for transportation and also increases its storage capabilities. The liquefaction process requires the natural gas to be cooled using various methods of cryogenic processes and also be depressurized to atmospheric conditions for easier and safer storage. Liquefied natural gas (LNG) transported in cryogenic vessels offers several advantages over pipeline transport of natural gas especially when the gas consuming areas are far away from the gas producing areas. Moreover, LNG as an automobile fuel has a definite edge over other fuels. This article presents an overview on the characteristics of LNG, present state of affairs of LNG, its import from overseas, compressed natural gas vs LNG as an automobile fuel, eco-friendliness of natural gas fuel, etc. It also discusses the potential of natural gas production from different sources.

Hydrogen generation and storage

12/01170 Biohydrogen production by *Anabaena* sp. PCC 7120 wild-type and mutants under different conditions: light, nickel, propane, carbon dioxide and nitrogen

Marques, A. E. *et al. Biomass and Bioenergy*, 2011, 35, (10), 4426–4434.
Increasing awareness of environmental problems caused by the current use of fossil fuel-based energy, has led to the search for alternatives. Hydrogen is a good alternative and the cyanobacterium *Anabaena* sp. PCC 7120 is naturally able to produce molecular hydrogen, photosynthetically from water and light. However, this H_2 is rapidly consumed by the uptake hydrogenase. This study evaluated the hydrogen production of *Anabaena* sp. PCC 7120 wild-type and mutants: $hupL^-$ (deficient in the uptake hydrogenase), $hoxH^-$ (deficient in the bidirectional hydrogenase) and $hupL^-/hoxH^-$ (deficient in both hydrogenases) on several experimental conditions, such as gas atmosphere (argon and propane with or without N_2 and/or CO_2 addition), light intensity (54 and 152 $\mu Em^{-2}s^{-1}$), light regime (continuous and light/dark cycles 16 h/8 h) and nickel concentrations in the culture medium. In every assay, the $hupL^-$ and $hupL^-/hoxH^-$ mutants stood out over wild-type cells and the $hoxH^-$ mutant. Nevertheless, the $hupL^-$ mutant showed the best hydrogen production except in an argon atmosphere under 16 h light/8 h dark cycles at 54 $\mu Em^{-2}s^{-1}$ in the light period, with 1 μM of $NiCl_2$ supplementation in the culture medium, and under a propane atmosphere. In all strains, higher light intensity leads to higher hydrogen production and if there is a daily 1% of CO_2 addition in the gas atmosphere, hydrogen production could increase 5.8 times, related to the great increase in heterocysts differentiation (five times more, approximately), whereas nickel supplementation in the culture medium was not shown to increase hydrogen production. The daily incorporation of 1% of CO_2 plus 1% of N_2 did not affect positively hydrogen production rate.

12/01171 Catalytic decomposition of methanol to carbon monoxide and hydrogen over palladium supported on $Ce_{0.65}$Zr0.30$La_{0.05}O_2$ and La–Al_2O_3

Zhao, M. *et al. Catalysis Today*, 2011, 175, (1), 430–434.
In this study, La–Al_2O_3 and $Ce_{0.65}Zr_{0.30}La_{0.05}O_2$ were used as support to prepare palladium catalyst for methanol decomposition to synthesis gas at low temperature. The catalysts were characterized by nitrogen adsorption, X-ray diffraction (XRD), temperature-programmed reduction (TPR), X-ray photoelectron spectroscopy (XPS) and NH_3-temperature-programmed desorption (TPD). XPS results confirm that palladium exists as oxidation state in the two catalysts and has strong interaction with ceria–zirconia solid solution. The result of H_2-TPR reveals that the reduction temperature of PdO slightly shifts to high temperature due to the strong interaction between palladium and $Ce_{0.65}Zr_{0.30}La_{0.05}O_2$. For Pd/$Ce_{0.65}Zr_{0.30}La_{0.05}O_2$ catalyst, the higher oxygen storage capacity is beneficial to the Pd species in a more active $Pd^{\delta+}$ state. Furthermore, the results of the methanol decomposition reaction show that the Pd/$Ce_{0.65}Zr_{0.30}La_{0.05}O_2$ catalyst has high catalytic activity. The conversion of methanol achieves 100% at 220 °C over Pd/$Ce_{0.65}Zr_{0.30}La_{0.05}O_2$.

12/01172 Catalytic hollow fibre membrane micro-reactor: high purity H_2 production by WGS reaction

García-García, F. R. *et al. Catalysis Today*, 2011, 171, (1), 281–289.
In this study, CuO/CeO_2 catalysts with a Cu content ranging from 5% to 40% were synthesized by sol–gel Pechini method and were tested in a fixed-bed reactor for water gas shift (WGS) reaction. The catalysts were characterized by XRD, N_2 adsorption isotherms at 77 K (S_{BET}) and H_2-TPR. Based on the catalytic activity results, 10% CuO/CeO_2, identified to be the most active catalyst, was deposited inside finger-like regions of an Al_2O_3 hollow fibre support for the further development of both catalytic hollow fibre micro-reactor (CHFMR) and catalytic hollow fibre membrane micro-reactor (CHFMMR) where Pd or Pd/Ag membrane was coated on the outer layer of the Al_2O_3 hollow fibre using a single or multilayer electroless plating (ELP) technique. The prepared catalytic membranes were characterized by SEM, EDX, and pure H_2 and Ar permeation. Also, a comparative study of the CO conversion obtained in the WGS reaction as a function of the reaction temperature (from 200 °C to 500 °C) in a fixed-bed reactor, a CHFMR, a Pd-CHFMMR and a Pd/Ag-CHFMMR, was performed showing that the conversion was highest in the Pd/Ag-CHFMMR.

12/01173 CFD investigating thermal-hydraulic characteristics and hydrogen generation from graphite–water reaction after SG tube rupture in HTR-10 reactor

Ferng, Y. M. and Chen, C. T. *Applied Thermal Engineering*, 2011, 31, (14–15), 2430–2438.
With inherent safety performance and high conversion efficiency, high-temperature gas-cooled reactors are the possible candidates for next-generation energy sources. A transient three-dimensional compressible CFD model is developed to investigate the thermal-hydraulic characteristics within the core under steady-state and accident conditions. The HTR-10, a graphite-moderated and helium-cooled reactor with a pebble bed core is selected for the present simulations. Four postulated accidents, with ruptures in one and two SG tubes, respectively, are investigated. In accidents, water is released into the core and reacts with graphite on fuel surface, causing H_2 and CO generation. Calculation results reveal that the concentration of H_2, produced by the chemical reaction of carbon with water, is not sufficient to induce hydrogen explosion during the postulated accidents. In addition, the peak coolant temperatures during the transients are predicted to be lower than the limiting value, confirming safety of the HTR-10 core in these accidents.

12/01174 Effect of upflow velocity and hydraulic retention time in anaerobic fluidized-bed reactors used for hydrogen production

Marques dos Reis, C. and Silva, E. L. *Chemical Engineering Journal*, 2011, 172, (1), 28–36.

The present study evaluated the influence of upflow velocity (V_{up}) applied to an anaerobic fluidized-bed reactor used for hydrogen production. For comparison, two reactors were used with different velocities: $1.24\,cm\,s^{-1}$ (R124) and $1.88\,cm\,s^{-1}$ (R188). Expanded clay was used as a support material for immobilization along with synthetic wastewater containing glucose as the main carbon source ($5000\,mg\,L^{-1}$). The reactor R124, which operated at the minimum fluidization velocity ($1.24\,cm\,s^{-1}$), had the best values for hydrogen production. The maximum hydrogen production rate was $2.21\,L\,h^{-1}\,L^{-1}$ for a hydraulic retention time (HRT) of 1 h, while the best hydrogen yield was $2.55\,mol\,H_2\,mol^{-1}$ glucose for an HRT of 2 h. The hydrogen content in the biogas was around 40.53–67.57%. A high amount of ethanol was produced, suggesting that a metabolic pathway via ethanol was preferable. In general, the reactor under the minimum velocity fluidization (R124) presented a greater production of hydrogen than R188 showing that should have a limit point in V_{up} till the hydrogen production is maximized.

12/01175 Eliminating methanogenic activity in hydrogen reactor to improve biogas production in a two-stage anaerobic digestion process co-digesting municipal food waste and sewage sludge

Zhu, H. *et al. Bioresource Technology*, 2011, 102, (14), 7086–7092.

Laboratory scale two-stage anaerobic digestion process model was operated for 280 days to investigate the feasibility to produce both hydrogen and methane from a mixture feedstock (1:1 (v/v)) of municipal food waste and sewage sludge. The maximum hydrogen and methane yields obtained in the two stages were 0.93 and 9.5 mL/mL feedstock. To eliminate methanogenic activity and obtain substantial hydrogen production in the hydrogen reactor, both feedstock and mixed liquor required treatment. The heat treatment (100 °C, 10 min) for feedstock and a periodical treatment (every 2–5 weeks, either heating, removal of biomass particles or flushing with air) for mixed liquor were effective in different extent. The methane production in the second stage was significantly improved by the hydrogen production in the first stage. The maximum methane production obtained in the period of high hydrogen production was more than two-fold of that observed in the low hydrogen production period.

12/01176 Enhanced hydrogen production by in situ CO_2 removal on $CaCeZrO_x$ nanocrystals

Sultana, K. S. and Chen, D. *Catalysis Today*, 2011, 171, (1), 43–51.

The CO_2 capture properties of a new nanocrystalline CaO-based mixed oxide ($CaCeZrO_x$) were studied in both TGA and a fixed bed reactor. The kinetics of CO_2 capture at dry conditions was compared between these two reactors. The application of the new CO_2 acceptor in sorption enhanced steam methane reforming was studied by a fixed-bed reactor in the presence of 40 wt% nickel hydrotalcite catalysts. Experimental results show that the new CO_2 acceptor, $CaCeZrO_x$ has a significantly improved CO_2 capture capacity and cyclic reaction stability compared to natural dolomites, because of the large pores and stable backbone structure. It has also been observed that the sorption enhanced steam methane reforming in the fixed bed reactor produces more than 95% H_2 in a single-step process. Increase in production of hydrogen and higher CO_2 capture capacity are also observed with an increase in the residence time of methane. Steam has a significant effect on the stability of the acceptors, but not very much on the kinetics and capacity of CO_2 capture. The capacity of CO_2 capture on the acceptors in the SESMR process cannot be predicted by the independent CO_2 capture kinetic study on acceptor alone. A synergy effect between the sorption enhanced reactions and CO_2 capture on the CO_2 capture capacity was observed on the all solid CaO-based CO_2 acceptors.

12/01177 Enhancement of photoelectrochemical activity of nanocrystalline CdS photoanode by surface modification with TiO_2 for hydrogen production and electricity generation

Zhong, M. *et al. Solar Energy*, 2012, 86, (2), 756–763.

Nanocrystalline CdS films on the FTO glass substrates using doctor-blade method were used as photoanodes in two different photoelectrochemical (PEC) cells for hydrogen production and electricity generation. The influence of surface modification by overcoating with a thin amorphous TiO_2 on the PEC performance of CdS films has also been investigated. It was found that TiO_2 content have a dominant effect on the performance of PEC cells. The optimized PEC cells with CdS/TiO_2 (1.8 wt% TiO_2 content) electrode showed a four-fold increase in hydrogen production and a five times enhancement of the cell efficiency (a maximum power conversion efficiency of 2.7%) compared to that of the unmodified one. Furthermore, surface modification has similar effect on these two PEC cells. The electrochemical investigation suggests that the TiO_2 layer on CdS reduces the interfacial charge recombination and induces a downward shift of the flat band potential in both PEC cells. This work reveals that the interfacial charge recombination is essentially critical for both hydrogen production and electricity generation.

12/01178 Fermentative hydrogen production from fresh leachate in batch and continuous bioreactors

Liu, Q. *et al. Bioresource Technology*, 2011, 102, (9), 5411–5417.

This research investigated hydrogen production from the fresh leachate originated from municipal solid wastes. It was found that fermentation of the leachate generated H_2 and was very much enhanced in the presence of additional phosphate in the batch reactor. The continuous expanded granular sludge bed (EGSB) reactor started to generate H_2 at day 20 and continued to 176 days with 120 mg/l of additional phosphate present. The highest chemical oxygen demand (COD) removal efficiency (66.9%) was achieved at liquid up-flow velocity of 3.7 m/h and hydraulic retention time of 12 h. Under proposed optimal operation conditions, the mean H_2 production rate reached up to 2155 ml/(l day). It was also found that over 80% liquid metabolites were acetic acid and ethanol, suggesting the ethanol-type fermentation was dominant in the bioreactor. These findings indicate that the fresh leachate can be used as the source for continuous hydrogen production.

12/01179 Forced flow boiling heat transfer of liquid hydrogen for superconductor cooling

Shirai, Y. *et al. Cryogenics*, 2011, 51, (6), 295–299.

Heat transfer from inner side of a heated vertical pipe to liquid hydrogen flowing upward was first measured at the pressure of 0.7 MPa for wide ranges of flow rates and liquid temperatures. The heat transfer coefficients in non-boiling regime for each flow velocity were well in agreement with the Dittus–Boelter equation. The heat fluxes at the inception of boiling and the departure from nucleate boiling (DNB) heat fluxes are higher for higher flow velocity and subcooling. It was found that the trend of dependence of the DNB heat flux on flow velocity was expressed by the correlation derived by an earlier study based on their data for subcooled flow boiling of water, although it has different propensity to subcooling.

12/01180 Hydrogen adsorption on functionalized graphene

Darkrim Lamari, F. and Levesque, D. *Carbon*, 2011, 49, (15), 5196–5200.

The hydrogen adsorption on basal graphite planes functionalized by hydrogen atoms is studied by molecular modelling and numerical simulation at temperatures of 77 K and 293 K up to high pressure. At 77 K and pressure of 1 MPa, on such an adsorbing surface, the excess hydrogen physisorption is estimated equal to ~7.0 wt%. At 293 K and 30 MPa, the excess physisorption reaches ~1.5 wt%. A comparison between the hydrogen adsorption properties of functionalized graphite basal planes and plain graphite basal planes is presented for materials exhibiting similar porosities.

12/01181 On-board H_2 generation by catalytic dehydrogenation of hydrocarbon mixtures or fuels

Lucarelli, C. *et al. Catalysis Today*, 2011, 175, (1), 504–508.

The partial dehydrogenation (PDh) of hydrocarbon blends may be a suitable way to produce H_2 on-board of automotives or airplanes to feed fuel cells and produce electric power, avoiding storage problems. In this work very interesting data have been collected using Jet A-1 surrogate and $Pt–Sn/\gamma\text{-}Al_2O_3$ catalysts, operating at 450 °C and feeding the vaporized hydrocarbon blend without any carrier gas. The use of Pt/Sn catalyst with 1:1 (w/w) ratio leads to the best compromise between activity and stability with time-on-stream, due to the formation of Pt-rich alloys. Nevertheless, all studied catalysts exhibited limited thio-tolerance. In optimized reaction conditions, H_2 productivity of $3000\,NL/kg_{cat}/h$, sufficient to produce 3 kW of electric power, considering purification steps and a fuel efficiency of 50%, was obtained.

12/01182 Photoassisted hydrogen production under visible light over NiO/ZnO hetero-system

Belhadi, A. *et al. Applied Energy*, 2011, 88, (12), 4490–4495.

Visible light driven water reduction is successfully achieved over the novel hetero-system NiO/ZnO. The capacitance measurement (C^{-2}–V) of NiO exhibits a positive slope, characteristic of *n* type conductivity, from which a flat band potential of $-0.80\,V_{SCE}$ and a density of $1.41 \times 10^{18}\,cm^{-3}$ are obtained. The correlation of the energy levels indicates that the photo electrons react with adsorbed H_2O molecules via ZnO interfacial mechanism. Two NiO compositions (4% and 10%) onto ZnO support are prepared by the impregnation technique. The electrons generated upon visible light in the conduction band of NiO, anchored uniformly on ZnO, diffuse to the interface for achieving the water reduction. NiO is photoelectrochemically stable by hole consumption reactions involving $S_2O_3^{2-}$ as sacrificial agent. The best performance is obtained in basic media on NiO (4%) with an evolution rate of 435 µmol h^{-1} (mg catalyst)$^{-1}$ and a quantum efficiency of 0.3%. The hetero-system has the thermodynamically force to drive the uphill reaction ($S_2O_3^{2-} + H_2O + 2OH^- \rightarrow 2SO_3^{2-} + 2H_2$, $\Delta G_f^o = 101.04$ kJ mol^{-1}).

12/01183 Thermodynamic assessment of hydrogen production and cobalt oxidation susceptibility under ethanol reforming conditions

de Ávila, C. N. *et al. Energy*, 2011, 36, (7), 4385–4395.

A comparative thermodynamic analysis of ethanol reforming reactions was conducted using an in-house code. Equilibrium compositions were estimated using the Lagrange multipliers method, which generated systems of non-linear algebraic equations, solved numerically. Effects of temperature, pressure and steam to ethanol, O_2 to ethanol and CO_2 to ethanol ratios on the equilibrium compositions were evaluated. The validation was done by comparing these data with experimental literature. The results of this work proved to be useful to foresee whether the experimental results follow the stoichiometry of the reactions involved in each process. Mole fractions of H_2 and CO_2 proved to be the most reliable variables to make this type of validation. Maximization of H_2 mole fraction was attained between 773 and 873 K, but maximum net mole production of H_2 was only achieved at higher temperatures (>1123 K). This work also advances in the thermodynamics of solid–gas phase interactions. A solid phase thermodynamic analysis was performed to confirm that Co^0 formation from CoO is spontaneous under steam reforming conditions. The results showed that this reduction process occurs only for temperatures higher than 430 K. It was also found that once reduced, Co based catalysts will never oxidize back to Co_3O_4.

12/01184 Thermolysis of methane in a solar reactor for mass-production of hydrogen and carbon nano-materials

Yeheskel, J. and Epstein, M. *Carbon*, 2011, 49, (14), 4695–4703.

Solar thermolysis of methane to produce hydrogen and carbon nanomaterials in a volumetric reactor/receiver with carbon particles cloud either priory seeded or chemically produced in the reactor, has been developed and tested. The reactor is based on absorbing of the concentrated solar radiation by the carbon particles and maintaining a reaction core at high temperature while the reactor walls are kept at relatively low temperatures, compatible with existing ceramic materials. The main advantage of the volumetric approach lies in its excellent heat transfer effectiveness and scalability to larger scales. As a result of computational fluid dynamics (CFD) analysis a compound reactor was designed and tested. The reactor's most important characteristics are: high reaction temperature, transparent window protection and directional streaming flow (tornado) without boundary layer separation. Experimentally, high temperatures (up to 1500 °C) in the reaction domain were achieved resulting in complete conversion of methane to hydrogen and solid carbon nano particles. Experiments were operated for periods of about 60 min with steady-state temperatures and reaction products. Organometallic catalysts were mixed together with the methane feed to produce multiwalled carbon nanotubes (MWCNT). In the catalytic experiments lower temperatures were maintained which, although resulted in lower methane conversion, enhanced the MWCNT production.

04 BY-PRODUCTS RELATED TO FUELS

12/01185 A new method for improving the thermal insulation properties of fly ash

Saygili, A. and Baykal, G. *Energy and Buildings*, 2011, 43, (11), 3236–3242.

In the autoclaved aerated concrete production, aluminium powder is used to create pores which lead to high thermal insulation property. In the present technique developed, snow or crushed ice is added to fly ash over optimum moisture content and compacted to obtain an increased porosity and a stronger matrix. The main objective of this study is to investigate the effect of various practical mix percentages of snow into fly ash and evaluation of their insulation properties. The optimum water content of fly ash was determined and additional snow with percentages of 10, 20 and 30 by weight are added to type C fly ash samples. Thermal conductivity tests were performed on samples to evaluate the insulation capability of the snow added fly ash samples where information is not readily available in the literature. The highest improvement in the thermal conductivity is obtained by adding 20% snow to fly ash samples over optimum moisture content. Higher percentages of snow addition resulted in interconnected voids, causing lower thermal conductivity performance. These findings can be utilized for non-structural insulating construction blocks and also as an insulation layer for embankments in permafrost areas.

12/01186 Characteristics of tar, NO_x precursors and their absorption performance with different scrubbing solvents during the pyrolysis of sewage sludge

Chen, H. *et al. Applied Energy*, 2011, 88, (12), 5032–5041.

Recently thermal utilizations of sewage sludge, especially pyrolysis and gasification, are regarded as promising technologies due to efficient utilization of fuel gas. In this study, characteristics of tar and NO_x precursors were investigated during the pyrolysis of sewage sludge. Moreover, absorption performance for tar and NO_x precursors were also studied by using four kinds of scrubbing mediums: cooking oil, diesel oil, BDF and water. The results showed that nitrogenous light PAHs were the major components of nitrogenous tar produced from the pyrolysis of sewage sludge. As for gravimetric tar and major nitrogenous tar compounds removal, cooking oil was the most suitable absorbent. With respect to NO_x precursors, it was concluded that HCN, sharing of about 39.5% of total nitrogen of the sewage sludge, was the main NO_x precursor gas whereas NH_3 content could be neglected. Absorption capacity of hydrophobic scrubbing mediums against NO_x precursor gases could be arranged as followed: diesel oil > cooking oil > BDF.

12/01187 Experimental study on the coal tar hydrocracking process in supercritical solvents

Gu, Z. *et al. Fuel*, 2012, 91, (1), 33–39.

In order to find the optimal operating parameters in high-temperature and low-temperature coal tar hydrocracking processes and to maximize the light oil yields, experimental studies have been carried out in a one-stage reactor in supercritical solvents. Xylene and gasoline were used as supercritical solvents to investigate their effects on the light oil yields. The results show that gasoline was more suitable as a supercritical solvent and that a suitable ratio of gasoline solvent to coal tar could result in higher light oil yields in both high- and low-temperature coal tar hydrocracking processes. The effects of different operating parameters, including temperature, hydrogen pressure, catalyst, and residence time, on light oil yield were tested. It was found that the yields of light oil from the two coal tar hydrocracking processes varied with the operating parameters in a similar manner. However, different values of the operating parameters gave rise to the maximum yields of light oil from the respective processes.

12/01188 Preparation and characterisation of demineralised tyre derived activated carbon

Chan, O. S. *et al. Carbon*, 2011, 49, (14), 4674–4687.

This study investigated the effect of demineralization and activation conditions on the physical and chemical properties of activated carbon adsorbents produced from waste tyre char. Experimental data showed that hydrochloric acid treatment prior to the activation is able to remove certain mineral contents such as zinc, calcium, sodium and others from the tyre char. The removal of some of the components which have catalytic effect on the activation increase the yield of the activated carbon and at the same time lower the ash content of the tyre activated carbon. The tyre demineralized activated carbons are generally mesoporous with a surface area up to 960 m^2/g and therefore are comparable to commercial products. The adsorption of phenol onto the tyre activated carbon was also tested and the Redlich–Peterson equilibrium isotherm model gave the best-fit to experimental data for the phenol using non-linear error functions.

12/01189 Process optimization for Cr(VI) adsorption onto activated carbons by experimental design

Özdemir, E. *et al. Chemical Engineering Journal*, 2011, 172, (1), 207–218.

A study on the adsorption of Cr(VI) onto raw and modified activated carbons was conducted and the process parameters were optimized using response surface methodology (RSM). Apricot stones have been converted to microporous activated carbon with considerably high surface area (1462 $m^2 g^{-1}$) by phosphoric acid activation. Produced carbons have been characterized by using different physicochemical methods. In order to determine the effects of process parameters namely temperature (20–60 °C), initial solution pH (2–6) and initial Cr(VI) concentration (30–60 mg L^{-1}) on Cr(VI) uptake from aqueous solution, a three-level, three-factor, Box–Behnken design has been employed. The second order mathematical model was developed by regression analysis of the experimental data obtained from 17 batch runs. The optimum pH, temperature and initial concentration were found to be 2.0, 60 °C, and 60 mg L^{-1}, respectively. Cr(VI) adsorption capacity was 262 mg g^{-1} at the optimum combination of process parameters. The enthalpy change of Cr(VI) adsorption was found to be 54.05 kJ mol^{-1}. Dynamic adsorption data were applied to pseudo-first-order and pseudo-second-order rate equations. Pseudo-second-order kinetic model well expressed Cr(VI) adsorption onto activated carbon. The results of both thermodynamic and kinetic study indicated the chemical interaction between Cr(VI) species and surface functional groups on carbon surface.

05 NUCLEAR FUELS

Scientific, technical

12/01190 A fundamental approach to specify thermal and pressure loadings on containment buildings of sodium cooled fast reactors during a core disruptive accident

Velusamy, K. *et al. Annals of Nuclear Energy*, 2011, 38, (11), 2475–2487.

Reactor containment building (RCB) is the ultimate barrier to the environment against activity release in any nuclear power plant. It has to be designed to withstand both positive and negative pressures that are credible. Core disruptive accident (CDA) is an important event that specifies the design basis for RCB in sodium cooled fast reactors. In this paper, a fundamental approach towards quantification of thermal and pressure loadings on RCB during a CDA, has been described. Mathematical models have been derived from fundamental conservation principles towards determination of sodium release during a CDA, subsequent sodium fire inside RCB, building up of positive and negative pressures inside RCB, potential of in-vessel sodium fire due to failed seals and temperature evolution in RCB walls during extended period of containment isolation. Various heating sources for RCB air and RCB wall and their potential have been identified. Scaling laws for conducting CDA experiments in small-scale water models by chemical explosives and the rule for extrapolation of water leak to quantify sodium leak in reactor are proposed. Validation of the proposed models and experimental simulation rules has been demonstrated by applying them to Indian prototype fast breeder reactor. Finally, it is demonstrated that in-vessel sodium fire potential is very weak and no special containment cooling system is essential.

12/01191 A three-dimensional thermal and fluid dynamics analysis of a gas cooled subcritical fast reactor driven by a D–T fusion neutron source

Angelo, G. *et al. Annals of Nuclear Energy*, 2011, 38, (12), 2734–2741.

The entire nuclear fuel cycle involves partitioning classification and transmutation recycling. The usage of a tokamak as neutron sources to burn spend fuel in a gas-cooled subcritical fast reactor (GCSFR) reduces the amount of long-lived radionuclide, thus increasing the repository capacity. This paper presents numerical thermal and fluid dynamics analysis for a gas cooled subcritical fast reactor. The analysis aim to determine the operational flow condition for this reactor, and to compare three distinct turbulence models (eddy viscosity transport equation, standard k–ε and SSG Reynolds stress) for this application. The model results are presented and discussed. The methodology used in this paper was developed to predict the coolant mass flow rate. It can be applied to any other gas-cooled reactor.

12/01192 Advanced fuel cycle scenarios for high temperature gas reactors

Choi, H. *Annals of Nuclear Energy*, 2011, 38, (11), 2338–2349.

This study evaluates nuclear fuel cycle scenarios which are based on recycling spent nuclear fuel for the sustainability of nuclear energy. Three fuel cycle scenarios, the light water reactor (LWR)–advanced recycling reactor (ARR) recycle, the LWR–high temperature gas reactor (HTGR)–ARR recycle, and the HTGR partial recycling fuel cycle, are assessed for their mass flow and electricity generation costs and the results are compared to those of the LWR once-through fuel cycle. The spent fuels are recycled in both the consolidated fuel treatment centre and the actinide management island, which are capable of reprocessing spent fuels by uranium extraction and pyrochemical processes, respectively. The mass flow calculations show that the transuranics which have a long-term radiation effect can be completely burned in the recycling fuel cycles, resulting in 350, 450 and 6 times reduction of TRU inventory for the LWR–ARR, LWR–HTGR–ARR and HTGR partial recycling fuel cycles, respectively, when compared to the once-through fuel cycle. The electricity generation costs of these fuel cycle scenarios were estimated to be 39.1, 34.9 and 25.7 USD/MW h(e), which are comparable to or smaller than that of the once-through fuel cycle. Although the candidate fuel cycles adopt reprocessing options which raise fuel cycle cost, increase in uranium cost and the advanced design of the HTGR can further reduce the advanced fuel cycle costs of the HTGR.

12/01193 Design of a model for BSA to meet free beam parameters for BNCT based on multiplier system for D–T neutron source

Rasouli, F. S. *et al. Annals of Nuclear Energy*, 2012, 39, (1), 18–25.

Extensive research has recently been carried out for the development of high-energy D–T neutron generators as neutron sources for BNCT. The energy of these high-energy neutrons must be reduced by designing a beam shaping assembly (BSA) to make them usable for BNCT. However, the neutron flux decreases drastically as neutrons pass through different materials of BSA. Therefore, it is very important to find ways to treat the neutrons economically. In this paper the possibility of using natural uranium as a neutron multiplier is investigated in order to increase the number of neutrons emitted from D–T neutron generator. According to the simulations and performed calculations, a sphere containing natural uranium as neutron multiplier was used to increase the number of neutrons generated by the D–T neutron generator. The energy of fast neutrons that are generated by D–T fusion reaction and amplified by neutron multiplier system is decreased using proper materials as moderators and fast neutron filters in BSA. The gamma rays which are generated as a result of neutron interaction with moderators are removed from neutron spectrum using bismuth as the gamma filter. Also, a thermal neutron absorber omits undesired low-energy neutrons which lead to a high radiation dose for the skin and soft tissues. The results show that passing neutrons through such a BSA causes the establishment of free beam parameters yet the reduction of the output beam intensity is unavoidable. The neutron spectrum related to BSA has a proper epithermal flux and the fast and thermal neutron fluxes are compatible with the IAEA recommended values.

12/01194 Design study on power flattening to sodium cooled large-scale CANDLE burning core with using thorium fuel

Okawa, T. *et al. Energy Conversion and Management*, 2012, 53, (1), 182–188.

The CANDLE (constant axial shape of neutron flux, nuclide densities and power shape during life of energy production) burn-up strategy is a unique and new burn-up concept. The previous CANDLE cores feature a relatively large peak-to-average power density and discharge burn-up distribution. Peaked power and burn-up distribution are undesirable, as they deteriorate economic performance. The objective of this paper is to study the feasibility of power flattening of sodium cooled large scale CANDLE reactors toward commercial use by using thorium fuel loading into the inner core zone. If the amount of thorium proper is chosen, net radial current of neutrons in the inner core becomes zero in the inner core, and at the boundary between inner and outer core enough neutrons leak from the uranium region and the net radial current is still zero at this point. In the outer region the neutrons leak outward. By this way, the power density distribution can be made flat in the inner core. In the present work, the power density profile is intended flatten for the metallic fuel CANDLE reactors by adding thorium uniformly in the inner core region. The authors also evaluate that the core radius and height have an effect on power flattening. The maximum axially integrated power density (radial peaking factor) decreases from 1.87 with only uranium fuel to 1.44 with uranium and thorium fuels. The power flattening with loading thorium fuel in the inner core zone creates higher power density and lower coolant velocity that allow higher thermal power and smaller pressure drop.

12/01195 Implementation of microbial processes in the performance assessment of spent nuclear fuel repositories

Behrends, T. *et al. Applied Geochemistry*, 2012, 27, (2), 453–462.

Present strategies for the long-term disposal of high-level nuclear wastes are based on the construction of repositories hundreds of metres below the earth surface. Although the surrounding host-rocks are relatively isolated from the light at the earth surface they are by no means lifeless. Microorganisms rule the deep part of the biosphere and it is well established that their activity can alter chemical and physical properties of these environments. Microbial processes can directly and indirectly affect radionuclide migration in multiple ways. Within 6th FP IP FUNMIG the interplay between microbial biofilms and radionuclides and the effect of microbially induced redox transformations of Fe on radionuclide mobility have been investigated. For the first time, formation of U(V) as a consequence of microbial U(VI) reduction in a multi-species biofilm was detected *in vivo* by combining laser fluorescence spectroscopy and confocal laser scanning microscopy. Furthermore, it was demonstrated that addition of U(VI) can lead to increased respiratory activity in a biofilm. Increased respiration in a biofilm can create microenvironments with lower redox potential, and hence induce reduction of radionuclides. Transient mobilization of U was observed in experiments with Fe oxides containing adsorbed U(VI) in which the activity of SO_4-reducing organisms was mimicked by sulfide addition. Faster reaction of sulfide with Fe oxides compared to U(VI) reduction, and decreasing U(VI) adsorption due to the transformation of Fe oxides into FeS can explain the observed intermittent U mobilization. The presented research on microbe-radionuclide interactions performed within FUNMIG addresses only a few aspects of the potential role of microorganisms in the performance assessment of nuclear waste repositories. For this reason, additionally, this article provides a cursory overview of microbial processes which were not studied within the FUNMIG project but are relevant in the context of performance assessment. The following aspects are presented: (a) the occurrence and metabolic activity of microorganisms of several proposed types of host-rocks, (b) the potential importance of microorganisms in the near-field of nuclear waste repositories, (c) indirect effects of microbial processes on radionuclide mobility in the repository far-field, (d) binding of radionuclides to microbial biomass, (e) microbial redox transformations of radionuclides, and (f) the implementation of microbial processes in reactive transport models for radionuclide migration.

12/01196 Minimization of actinide waste by multi-recycling of thoriated fuels in the EPR reactor

Rose, S. J. *et al. Annals of Nuclear Energy*, 2011, 38, (11), 2619–2624.
The multi-recycling of innovative uranium/thorium oxide fuels for use in the European pressurized water reactor (EPR) has been investigated. If increasing quantities of ^{238}U, the fertile isotope in standard UO_2 fuel, are replaced by ^{232}Th, then a greater yield of new fissile material (^{233}U) is produced during the cycle than would otherwise be the case. This leads to economies of natural uranium of around 45% if the uranium in the spent fuel is multi-recycled. In addition it is shown that minor actinide and plutonium waste inventories are reduced and hence waste radio-toxicities and decay heats are up to a factor of 20 lower after 10^3 years. Two innovative fuel types named S90 and S20, ThO_2 mixed with 90% and 20% enriched UO_2 respectively, are compared as an alternative to standard uranium oxide (UOX) and uranium/plutonium mixed oxide (MOX) fuels at the longest EPR fuel discharge burn-ups of 65 GWd/t. Fissile and waste inventories are examined, waste radio-toxicities and decay heats are extracted and safety feedback coefficients are calculated. Finally, the economics of such strategies are discussed.

12/01197 Reactivity feedback coefficients of a low enriched uranium fuelled material test research reactor at end-of-life

Muhammad, F. *Annals of Nuclear Energy*, 2011, 38, (12), 2836–2839.
The reactivity feedback coefficients at end-of-life of a material test reactor fuelled with low enriched uranium fuel were calculated. The reactor used for the study was the IAEA's 10 MW benchmark reactor. Simulations were carried out to calculate the different reactivity feedback coefficients including Doppler feedback coefficient, reactivity coefficient for change of water temperature and reactivity coefficient for change of water density. Nuclear reactor analysis codes including WIMS-D4 and CITATION were employed to carry out these calculations. It was observed that the magnitude of all the reactivity feedback coefficients increased at end of life of the reactor by almost 2–5%.

12/01198 Spent fuel pool storage calculations using the ISOCRIT burnup credit tool

Kucukboyaci, V. N. and Marshall, W. J. *Annals of Nuclear Energy*, 2012, 39, (1), 9–14.
In order to conservatively apply burnup credit in spent fuel pool criticality safety analyses, Westinghouse has developed a software tool, ISOCRIT, for generating depletion isotopics. This tool is used to create isotopics data based on specific reactor input parameters, such as design basis assembly type; bounding power/burnup profiles; reactor specific moderator temperature profiles; pellet percentage theoretical density; burnable absorbers, axial blanket regions, and bounding ppm boron concentration. ISOCRIT generates burnup dependent isotopics using PARAGON; Westinghouse's state-of-the-art and licensed lattice physics code. Generation of isotopics and passing the data to the subsequent 3D KENO calculations are performed in an automated fashion, thus reducing the chance for human error. Furthermore, ISOCRIT provides the means for responding to any customer request regarding re-analysis due to changed parameters (e.g. power uprate, exit temperature changes, etc.) with a quick turnaround.

12/01199 Theory and calculation of ^{135}Xe concentration time evolution for the nuclear power plant CNA II

Moreira, O. *Annals of Nuclear Energy*, 2012, 39, (1), 62–69.
In this report the theory to describe ^{135}Xe and ^{135}I concentration time evolutions is developed, for calculations applied to systems like nuclear reactors at power plants. Here, different from most of theories utilized, the ^{135}I concentration time evolution equation is corrected to iodine absorption. Reasons for both the occurrence of the xenon peak after a reactor power change and the reactor power limit value for the existence of this peak are also explained. Results for xenon and iodine concentrations performed for nuclear power plant CNA II agree with other calculations and previous works done for this installation.

12/01200 Utilization of thorium in a gas turbine-modular helium reactor with alternative fuels

Şahin, H. and Erol, Ö. *Energy Conversion and Management*, 2012, 53, (1), 224–229.
In this study, performances of two different types of nuclear fuels (reactor grade plutonium, RGrPu, and minor actinides, MA) acquired from the reactor operations combined with thorium in a gas turbine-modular helium reactor were investigated and compared with the uranium fuel designed for this reactor. In this way, 50% ThO_2–50% $RGrPuO_2$ (50%RGrPu), 10% ThO_2–90% $RGrPuO_2$ (90%RGrPu) and 10% ThO_2–90% MAO_2 (MA) mixtures were compared with the reference low enriched uranium (original fuel) fuel. By using MCNP5 1.4 with ENDF/B-VI data library and MONTEBURNS 2.0 performance calculations were made and operation time (the time passed until the k_{eff} value reached a level of 1.02) and burn-up values were used in the comparison of these fuels. Operation time for original fuel, MA, 50%RGrPu and 90%RGrPu mixtures were found as 515, 565, 765 and 2315 days with burn-up values of 47.7, 71.94, 75.1 and 213.4 GWd/MTU, respectively.

Economics, policy, supplies, forecasts

12/01201 A micro-XAS/XRF and thermodynamic study of $Ce^{III/IV}$ speciation after long-term aqueous alteration of simulated nuclear waste glass: relevance for predicting Pu behavior?

Curti, E. *et al. Applied Geochemistry*, 2012, 27, (1), 56–63.
In the present study, the dissolution and mobilization of Ce introduced in a simulated nuclear waste glass (MW) as a surrogate of Pu was investigated after leaching in pure water over 12 a at 90 °C and pH ~ 9.6. The microscopic distribution and oxidation state of Ce in the altered glass were studied using micro-X-ray fluorescence (micro-XRF) mapping techniques and micro-X-ray near-edge absorption spectroscopy (micro-XANES). Distribution maps of Ce^{III} and Ce^{IV} were obtained by recording the L_α fluorescence emission at two different incident X-ray energies, coinciding with the maximum contrast between Ce^{III} and Ce^{IV} fluorescence intensities. The micro-XRF maps revealed that Ce was dominantly present as oxidized species (Ce^{IV}) in the original glass. After dissolution from the glass matrix, Ce^{IV} was partly reduced and re-immobilized as Ce^{III} at grain boundaries or in the interstitial spaces between the glass particles. The concentration of Ce^{III} was found to correlate with the spatial distribution of secondary Mg-clay formed during the aqueous corrosion as the main glass alteration product. Micro-XANES spectra collected at locations representative of both altered and non-altered glass domains confirmed the findings obtained by the redox mapping. Because redox-sensitive elements in the pristine MW glass (Fe, Cr, Se) occur almost exclusively as oxidized species, reduction of Ce^{IV} was probably mediated by an external source of reductants, such as Fe(0) from the steel reaction vessel. These results, in conjunction with an Eh–pH stability diagram of the $Ce^{III/IV}$–O–H–C^{IV}–P–S^{VI}–Na–Cl system, indicate that the glass was leached at relatively low oxidation potentials (Eh < 0.2 V). However, the comparison with an equivalent Eh–pH diagram for Pu revealed that at comparable pH and water composition the reduction of Pu^{IV} to Pu^{III} would require considerably more reducing conditions (Eh < –0.3 V). It is, therefore, concluded that Ce is not a good chemical analogue of Pu, in spite of its wide use as a surrogate in simulated radioactive waste.

12/01202 A nuclear-powered north Africa: just a desert mirage or is there something on the horizon?

Jewell, J. *Energy Policy*, 2011, 39, (8), 4445–4457.
All of the north African countries have plans to develop nuclear power. If successful, nuclear energy could supply up to 9–15% of all electricity consumption in the region by 2030. How realistic are these plans and under what conditions can they be implemented? This paper seeks to answer this question by analysing the motivations and capacities for deploying nuclear energy in the five north African countries by examining both regional and national factors. These factors are compared to similar characteristics of the countries with existing nuclear power programs using a series of quantitative indicators. While all five countries have strong motivations to develop nuclear power, which result from the high growth rates in demand for electricity and energy security concerns, their financial and institutional capacities to deploy nuclear energy vary and are generally lower than in those countries which already operate nuclear power plants. Most likely, north Africa will need to rely on external assistance to implement its nuclear energy plans. The article identifies three scenarios of nuclear power development from the interplay between internal and external factors, particularly the success of renewable energy projects and the ability to attract international investment in nuclear power.

12/01203 An integrated simulation framework for the performance assessment of radioactive waste repositories

Cadini, F. *et al. Annals of Nuclear Energy*, 2012, 39, (1), 1–8.

An integrated framework for a process-driven performance assessment of radioactive waste repositories is presented. Key features of the proposed modelling strategy include: (1) the use of Monte Carlo-based simulation to model radionuclides migration at the repository scale, which allows simple management of realistic scenarios and (2) the adoption of a numerical code to provide realistic descriptions of the dynamics of radionuclide transport in natural groundwater bodies at the geosphere scale, from the release location to possible human intake occurrence. While repository-scale simulations are performed by the in-house code MASCOT, the subsequent groundwater flow and transport fields are depicted by means of the widely known and extensively used numerical codes MODFLOW and MT3DMS. An application to a realistic case study is presented to show the feasibility of the approach.

12/01204 Experience curve analysis on South Korean nuclear technology and comparative analysis with South Korean renewable technologies

Kim, D. W. and Chang, H. J. *Energy Policy*, 2012, 40, 361–373.

Increasing awareness on environmental damage and climate change has induced many nations to engage in green growth. South Korea, as one of the largest consumers of energy, is no exception and has shown its determination to pursue green growth in the future. In order to do so, South Korea plans to substitute fossil fuel with alternative sources in electricity generation. However, the key constraint to green growth is the high cost faced by renewable electricity generation. Fortunately, nuclear energy can serve as an economic alternative to fossil fuel. To achieve carbon dioxide emission reduction and faster economic growth, it is wise to analyse prospects of alternatives using experience curve framework. The results and industry background are consistent for nuclear technology, and the results suggest that nuclear should serve as the main substitute. Consideration of policy risk inherent in renewable also strengthens the argument. Renewable technologies, on the other hand, showed overstated learning capacity that is partially inconsistent with technological background. Nevertheless, the renewable (photovoltaic and fuel cell) should help nuclear marginally in substituting fossil fuel in South Korea's electricity generation.

12/01205 Loss of flow accident and its mitigation measures for nuclear systems with SCWR-M

Xu, Z. *et al. Annals of Nuclear Energy*, 2011, 38, (12), 2634–2644.

Based on a revised version of RELAP5, which can be used for supercritical pressure calculation, a model of mixed spectrum SCWR (SCWR-M) system is established. To analyse the transient behaviour of SCWR-M and develop mitigation measures during loss of flow accident (LOFA), some important parameters, e.g. reactor coolant pump (RCP) coast-down time, reactor pressure vessel (RPV) upper water volume and safety injection flow, etc., are chosen for the parametric analysis. The results achieved so far indicate that the SCWR-M system design is feasible and promising. Three important mitigation measures for LOFA of SCWR-M are derived from the results: RCP coast-down time of more than 15 s, RPV upper water volume of more than 27 m^3, and safety injection of more than 5% of the system design flow.

12/01206 Quantification model for estimating the radiological risks of decommissioning processes in nuclear facilities

Jeong, K.-S. *et al. Annals of Nuclear Energy*, 2011, 38, (11), 2612–2618.

This paper proposes a model for the quantification and estimating the radiological risks of decommissioning processes in nuclear facilities. Based on fuzzy linguistic variables, the membership function and inference rules were developed for quantifying the radiological risks of nuclear decommissioning processes. Also, the fuzzy inference system was developed and the proposed method was applied to the process of concrete decommissioning. The proposed model and system is flexible in that it allows a fast-computation of the subjective expert opinion when one or several input factors change. It is believed that the suggested model and system can be applied to evaluate the safety of complex systems by only changing the variable and inputs.

12/01207 Reliability block diagram with general gates and its application to system reliability analysis

Kim, M. C. *Annals of Nuclear Energy*, 2011, 38, (11), 2456–2461.

For those systems that can be modelled with perfect nodes and unreliable arcs such as communication systems, a reliability graph with general gates (RGGG) was developed. Similarly, for more efficient system reliability analysis of those systems that can be modelled with unreliable nodes and perfect arcs, a reliability block diagram with general gates (RBDGG) was developed as an intuitive and easy-to-use method for system reliability analysis. One of the unique characteristics of RBDGG is to allow node connection relations of general gates such as the AND gate and the *k*-out-of-*n* gate other than the OR gate connection relation of the conventional reliability block diagram (RBD). Mathematical formulations for RBDGG and a method of mapping a RBDGG model into an equivalent Bayesian network model without losing the one-to-one matching characteristic of the RBDGG for quantitative analysis is also provided. With the application to two example systems, the usefulness of the proposed RBDGG is demonstrated.

12/01208 Secure software configuration management processes for nuclear safety software development environment

Chou, I.-H. *Annals of Nuclear Energy*, 2011, 38, (10), 2174–2179.

The main difference between nuclear and generic software is that the risk factor is infinitely greater in nuclear software – if there is a malfunction in the safety system, it can result in significant economic loss, physical damage or threat to human life. However, secure software development environment have often been ignored in the nuclear industry. In response to the terrorist attacks on 11 September 2001, the US Nuclear Regulatory Commission (USNRC) revised the Regulatory Guide (RG 1.152–2006) 'Criteria for use of computers in safety systems of nuclear power plants' to provide specific security guidance throughout the software development life cycle. Software configuration management (SCM) is an essential discipline in the software development environment. SCM involves identifying configuration items, controlling changes to those items, and maintaining integrity and traceability of them. For securing the nuclear safety software, this paper proposes a secure SCM processes (S^2CMP) which infuses regulatory security requirements into proposed SCM processes. Furthermore, a process flow diagram is adopted to describe S^2CMP, which is intended to enhance the communication between regulators and developers.

06 ELECTRICAL POWER SUPPLY AND UTILIZATION

Scientific, technical

12/01209 A generalized power flow analysis for distribution systems with high penetration of distributed generation

Farag, H. E. *et al. Electric Power Systems Research*, 2011, 81, (7), 1499–1506.

In this paper, the element incidence matrix has been extended to develop a comprehensive three-phase distribution system power flow program for radial topology. Three-phase overhead or underground primary feeders and double-phase or single-phase line sections near the end of the feeder laterals have been considered. Unbalanced loads with different types including constant power, constant current and constant impedance are modelled at the system buses. Substation voltage regulator (SVR) consisting of three single phase units connected in wye or two single-phase units connected in open delta are modelled to satisfy the desired voltage level along the feeder. The mathematical model of distributed generation (DG) connected as PQ and PV buses are integrated into the power flow program to simulate the penetration of DGs in the distribution systems. The proposed method has been tested and compared with different IEEE test feeders result. The developed algorithm has been used to study the impact of both SVR and high penetration of DG on voltage profile and system power losses.

12/01210 Bioelectricity generation enhancement in a dual chamber microbial fuel cell under cathodic enzyme catalyzed dye decolorization

Bakhshian, S. *et al. Bioresource Technology*, 2011, 102, (12), 6761–6765.

Enzymatic decolorization of reactive blue 221 (RB221) using laccase was investigated in a dual-chamber microbial fuel cell (MFC). Suspended laccase was used in the cathode chamber in the absence of any mediators in order to decolorize RB221 and also improve oxygen reduction reaction in the cathode. Molasses was utilized as low cost and high strength energy source in the anode chamber. The capability of MFC for simultaneous molasses and dye removal was investigated. A decolorization efficiency of 87% was achieved in the cathode chamber and 84% COD removal for molasses was observed in the anode chamber. Laccase could catalyse the removal of RB221 and had positive effect on MFC performance as well. Maximum power density increased about 30% when enzymatic decolorization was performed in the cathode chamber.

12/01211 Comparative evaluation of different power management strategies of a stand-alone PV/Wind/PEMFC hybrid power system

Dursun, E. and Kilic, O. *International Journal of Electrical Power & Energy Systems*, 2012, 34, (1), 81–89.

This study presents different power management strategies of a stand-alone hybrid power system. The system consists of three power generation systems, photovoltaic panels, a wind turbine and a proton exchange membrane fuel cell. Photovoltaic cells and wind turbine are the main supply for the system, and the fuel cell performs as a backup power source. Therefore, continuous energy supply needs energy storing devices. In this proposed hybrid system, gel batteries are used. The state of charge, charge-discharge currents are affecting the battery energy efficiency. In this study, the battery energy efficiency is evaluated with three different power management strategies. The control algorithm is using Matlab Simulink.

12/01212 Coordinating cross-border congestion management through auctions: an experimental approach to European solutions

Jullien, C. *et al*. *Energy Economics*, 2012, 34, (1), 1–13.

Competition among producers within an integrated electricity system is impeded by any limited transmission capacity there may be at its borders. Two alternative market mechanisms have recently been designed to organize the allocation of scarce transmission capacity at cross-border level: (i) the 'implicit auction', already used in some countries, and (ii) the 'co-ordinated explicit auction', proposed by the European transmission system operators (ETSO) but not yet implemented. The main advantage of the explicit auction is that it allows each country to keep its own power exchange running. In the European institutional context, this is seen as a factor of success of a market reform, although the explicit auction (not coordinated) is known to be less efficient than the implicit mechanism. The addition of a coordination dimension in the explicit auction is intended to solve problems of international flows. The authors use the experimental methodology to identify and compare in a laboratory setting the efficiency properties of these two market mechanisms, given a market structure similar to the existing one in continental Europe, i.e. a competitive oligopoly. The main result highlights the inefficiency of the co-ordinated explicit auction compared to the performance of the implicit auction, measured in terms of both energy prices and transmission capacity allocation. The authors suggest that the poor performance of the co-ordinated explicit auction in the laboratory is due to the level of individual expectations about both energy and transmission prices that the mechanism demands. One solution to resolve this problem when the mechanism is implemented in the field would be to design an additional and secondary market for 'used' transmission capacity.

12/01213 Efficiency assessment and benchmarking of thermal power plants in India

Shrivastava, N. *et al*. *Energy Policy*, 2012, 40, 159–176.

Per capita consumption of electricity in India is many folds lesser than Canada, USA, Australia, Japan, China and world average. Even though, total energy shortage and peaking shortage were recorded as 11.20% and 11.85%, respectively, in 2008–2009 reflecting non-availability of sufficient supply of electricity. Performance improvement of very small amount can lead to large contribution in financial terms, which can be utilized for capacity addition to reduce demand supply gap. Coal-fired thermal power plants are main sources of electricity in India. In this paper, relative technical efficiency of 60 coal-fired power plants has been evaluated and compared using CCR and BCC models of data envelopment analysis. Target benchmark of input variables has also been evaluated. Performance comparison includes small versus medium versus large power plants and also state owned versus centrally owned versus privately owned. Result indicates poor performance of few power plants due to over use of input resources. Finding reveals that efficiency of small power plants is lower in comparison to medium and large category and also performance of state-owned power plants is comparatively lower than central and privately owned. The study also suggests different measures to improve technical efficiency of the plants.

12/01214 Electrical double layer capacitors with activated sucrose-derived carbon electrodes

Wei, L. and Yushin, G. *Carbon*, 2011, 49, (14), 4830–4838.

Electrical double layer capacitors (EDLCs) with activated sucrose-derived carbons (ASCs) as electrodes are reported. The carbons were prepared by the pyrolysis of sucrose followed by the activation with CO_2 gas for 1–5 h at 900 °C to tune the pore size distribution and the specific surface area (SSA). The porosity of the ASCs has been characterized using N_2 and CO_2 adsorption measurements. The activation increased the SSA from ~200 to $3000\,m^2\,g^{-1}$ and produced pores mostly in the 0.4–2 nm range. The pyrolysis of sucrose without CO_2 activation produces a carbon with specific capacitance as low as $4\,F\,g^{-1}$, whereas selected ASCs exhibit specific capacitance in excess of $160\,F\,g^{-1}$ and excellent frequency response in a two-electrode EDLC cell with 1 M H_2SO_2 electrolyte. The activation time of 4 h resulted in the most promising electrochemical performance. Excellent ASC stability was confirmed by extensive electrochemical characterization after 10,000 charge–discharge cycles.

12/01215 Electricity production in membrane-less microbial fuel cell fed with livestock organic solid waste

Lee, Y. *et al*. *Bioresource Technology*, 2011, 102, (10), 5831–5835.

Two different MFC configurations designed for handling solid wastes as a feedstock were evaluated in batch mode: a single compartment combined membrane-electrodes (SCME) design; and a twin-compartment brush-type anode electrodes (TBE) design (reversed T-shape MFC with two-air cathode) without a proton exchange membrane (PEM). Cattle manure was tested as a model livestock organic solid waste feedstock. Under steady conditions, voltage of 0.38 V was recorded with an external resistance of 470 Ω. When digested anaerobic sludge was used as the seed in the SCME design, a maximum power density of $36.6\,mW/m^2$ was recorded. When hydrogen-generating bacteria (HGB) were used as the seed used in the TBE design, a higher power density of $67\,mW/m^2$ was recorded.

12/01216 Evaluation of maximum allowable capacity of distributed generations connected to a distribution grid by dual genetic algorithm

Yang, N.-C. and Chen, T.-H. *Energy and Buildings*, 2011, 43, (11), 3044–3052.

This paper proposes a dual genetic algorithm based approach to evaluate the maximum allowable capacity of distributed generations (DGs) connected to a distribution grid. The uncertainties in the existing deterministic approaches for evaluating the steady-state voltage deviation due to distributed generation are discussed as well. Nowadays, deterministic approaches are widely adopted by those who propose the interconnection of DGs. However, the existing deterministic approaches overlook some operation conditions that may give rise to an incorrect result and lead to a wrong decision in practical applications. In this paper, various factors affecting steady-state voltage deviation are discussed first. Then, a maximum allowable DG capacity evaluation approach based on the dual genetic algorithm is proposed. Finally, the uncertainties of the existing deterministic approaches are discussed. It is intended as reference for utility engineers processing DG interconnection applications.

12/01217 Extraneous instabilities arising in power systems with non-synchronous distributed energy resources

Milano, F. *International Journal of Electrical Power & Energy Systems*, 2012, 34, (1), 174–176.

This short communication describes an extraneous instability that can be observed when solving time domain simulations for power systems with inclusion of non-synchronous distributed energy resources such as those based on voltage source converters and asynchronous generators. The instability object of the paper is caused by the interaction of (i) synchronous machines modelled using a synchronous reference speed and (ii) non-synchronous generators whose controllers depend on a $d-q$ transformation. The paper also provides two simple solutions able to remove such extraneous instabilities. The New England 39-bus benchmark system is used for testing the proposed solutions.

12/01218 Modelling and analysis of a power line communication system with QPSK modem for renewable smart grids

Kabalci, E. *et al*. *International Journal of Electrical Power & Energy Systems*, 2012, 34, (1), 19–28.

Monitoring and metering processes are required to be performed in renewable energy conversion systems like smart grid applications of the conventional grid system. These processes concerning renewable energy sources are analysed in this paper in order to propose a solution for solar power systems. The DC–AC conversion system proposed in this paper covers a solar power plant with a maximum power point tracking system and IGBT based three-phase inverter to generate three-phase AC line voltages. The modelled transmission line is not only used to carry the generated voltage but also to transmit the generated power rate of the solar plant in real-time. The power line communication (PLC) infrastructure employed is based on quadrature phase shift keying (QPSK) modems. In order to overlap QPSK modulated data to the three-phase transmission line at the inverter and grid sides a coupling interface is also designed in the study. The current, voltage and power data generated by the photovoltaic (PV) panels are successfully monitored over transmission lines owing to the developed system. As a result, additional monitoring costs are eliminated by using the proposed technique instead of SCADA or ethernet-based systems.

12/01219 On the application of wavelet transform for symmetrical components computations in the presence of stationary and non-stationary power quality disturbances

Morsi, W. G. and El-Hawary, M. E. *Electric Power Systems Research*, 2011, 81, (7), 1373–1380.

Symmetrical components method allows systematic analysis of unbalanced three-phase systems. This method represents the backbone for many applications in an electric power system (EPS) such as fault analysis, power system protection, power and energy measurements. Moreover, with the increased penetration of plug-in hybrid electric vehicles (PHEVs), studying and evaluating the distribution system unbalance considering power quality disturbance pronounced by fleet of these vehicles, becomes a necessity. In time-invariant polluted environment, the measurements of the symmetrical components for the fundamental and harmonic components could be performed using Fourier basics. However Fourier-based techniques are unsuitable in the presence of any time-variant power quality disturbance which is typically the case when considering PHEVs and other non-linear industrial process such as computer numerical control (CNC) machines. In this paper, time-frequency expressions for the symmetrical components are developed using different wavelet transforms: discrete wavelet transform (DWT), wavelet packet transform (WPT) and stationary wavelet transform (SWT). The paper also includes a comparative study of the results obtained when applying the developed approach using different wavelet basis functions, such as Daubechies, Coiflets and Symlets into three case studies (two synthetic and one real) including unbalanced three-phase system under different operating conditions while considering different kind of disturbances. The results are analysed and conclusions are presented. The outcomes of this study lay the ground for further studies in unbalanced distribution system with high penetration of PHEVs, two-way protection devices for smart grid and power quality evaluation.

12/01220 Optimum distributed generation placement with voltage sag effect minimization

Biswas, S. *et al. Energy Conversion and Management*, 2012, 53, (1), 163–174.

The present paper proposes a new formulation for the optimum distributed generator (DG) placement problem which considers a hybrid combination of technical factors, like minimization of the line loss, reduction in the voltage sag problem, etc., and economical factors, like installation and maintenance cost of the DGs. The new formulation proposed is inspired by the idea that the optimum placement of the DGs can help in reducing and mitigating voltage dips in low voltage distribution networks. The problem is configured as a multi-objective, constrained optimization problem, where the optimal number of DGs, along with their sizes and bus locations, are simultaneously obtained. This problem has been solved using genetic algorithm, a traditionally popular stochastic optimization algorithm. A few benchmark systems radial and networked (like 34-bus radial distribution system, 30 bus loop distribution system and IEEE 14 bus system) are considered as the case study where the effectiveness of the proposed algorithm is aptly demonstrated.

12/01221 Performance and reliability of electrical power grids under cascading failures

Chang, L. and Wu, Z. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (8), 1410–1419.

The stability and reliability of electrical power grids are indispensable to the continuous operation of modern cities and critical for preparedness, response, recovery and mitigation in emergence management. Because present power grids in China are often running near their critical operation points, they are especially vulnerable and sensitive to external disturbances such as hurricanes, earthquakes and terrorist attacks, which may trigger cascading failures or blackouts. This paper describes a quantitative investigation of the stability and reliability of power grids with a focus on cascading failures under external disturbances. The 118-bus (substation) power network in Hainan, China is employed as a case study to investigate the risk of cascading failure of the regional power grids. System performance and reliability of the power grids are evaluated under two hypothetical scenarios (seismic impact and intentional disturbance) that could trigger cascading failures. By identifying the most vulnerable (critical) edges and nodes, the robustness of the power network is evaluated under the triggered cascading failures. It is found that the system reliabilities could decline as much as 95% during the triggered cascading failure. This paper also explores the use of concepts from modern complex network theories such as state transition graph and characteristic length to understand the complex mechanism of cascading failures. The findings could be useful for power industries and emergency managers to evaluate the vulnerability of power systems, understand the risk of blackout induced by cascading failures, and improve the resilience of power systems to external disturbances.

12/01222 Recovery estimation for over-current test of non-inductive fault current limiters using numerical analysis

Kim, Y. J. *et al. Cryogenics*, 2011, 51, (6), 261–265.

When an HTS coated conductor (CC) is used as a conductor of a superconducting fault current limiter (SFCL), the CC is expected to be exposed to the over-current and temperature of the CC is expected to be increased rapidly by electrical joule heating. Because the CC is a composite tape, thermal and electrical properties of composite materials could affects over-current limiting capacity and recovery time of SFCL. This paper presents experimental and numerical results of over-current test and recovery time measurement test on four bifilar wound SFCL modules. The temperature transitions of the samples were estimated from total electrical resistance of the coils. The authors fabricated one bifilar solenoid coil and three bifilar pancake coils whose cryogenic conditions were different from the other coils. An numerical model was also fabricated to simulate the temperature transition and the numerical results were compared with experimental results.

12/01223 Reliability based optimum location of distributed generation

Banerjee, B. and Islam, S. M. *International Journal of Electrical Power & Energy Systems*, 2011, 33, (8), 1470–1478.

The increasing penetration of distributed generation and changing electricity industry necessitates that maximum benefit is obtained from distributed generators. Due to the importance of reliability of supply, the optimum location to maximize reliability has been investigated. A value based approach is used so that costs associated with levels of reliability may be used as an indicator. These are determined using probabilistic approaches which is a departure from the traditional deterministic criteria currently used.

12/01224 Solid phase microbial fuel cell (SMFC) for harnessing bioelectricity from composite food waste fermentation: influence of electrode assembly and buffering capacity

Mohan, S. V. and Chandrasekhar, K. *Bioresource Technology*, 2011, 102, (14), 7077–7085.

Solid phase microbial fuel cells (SMFC; graphite electrodes; open-air cathode) were designed to evaluate the potential of bioelectricity production by stabilizing composite canteen based food waste. The performance was evaluated with three variable electrode-membrane assemblies. Experimental data depicted feasibility of bioelectricity generation from solid state fermentation of food waste. Distance between the electrodes and presence of proton exchange membrane (PEM) showed significant influence on the power yields. SMFC-B (anode placed 5 cm from cathode-PEM) depicted good power output (463 mV; 170.81 mW/m^2) followed by SMFC-C (anode placed 5 cm from cathode; without PEM; 398 mV; 53.41 mW/m^2). SMFC-A (PEM sandwiched between electrodes) recorded lowest performance (258 mV; 41.8 mW/m^2). Sodium carbonate amendment documented marked improvement in power yields due to improvement in the system buffering capacity. SMFCs operation also documented good substrate degradation (COD, 76%) along with bio-ethanol production. The operation of SMFC mimicked solid-sate fermentation which might lead to sustainable solid waste management practices.

12/01225 Symmetrical and unsymmetrical short-circuit current of squirrel-cage and doubly-fed induction generators

Sulla, F. *et al. Electric Power Systems Research*, 2011, 81, (7), 1610–1618.

A general method for calculating the short-circuit currents of a squirrel-cage (SCIG) and a doubly fed induction generator (DFIG) using crowbar protection is presented. The method results in an approximate analytic expression that allows calculating the SCIG and DFIG short-circuit currents as a function of time for symmetrical and unsymmetrical faults in the power system. The presented theoretical analysis highlights some important differences between the short-circuit behaviour of the SCIG and the DFIG with high crowbar resistance. A comparison with time simulations of the same model shows that the proposed approach leads to results whose accuracy is comparable to those obtained through dynamic simulations and may be sufficient to replace the use of simulations in many contexts, e.g. calculation of maximum current, calculation of its DC and AC components and short-circuit calculations for protection relay settings.

12/01226 The potential contribution of thermo power plants in the Brazilian electric sector

Pinto, C. P. and Walter, A. *Energy*, 2011, 36, (6), 3667–3674.

This paper aims to analyse particularities of the Brazilian electric system and to evaluate the potential contribution of thermal power plants targeting at its higher reliability. In special, the aim is at analysing the insertion of thermal power production in the present context in which hydroplants start to be built in the Amazon area with small reservoir capacity. An assessment of the behaviour of the energy inflows and of the regularization capacity of the Brazilian hydropower system emphasizes the need for having a good quality thermal power expansion. The power production from sugarcane residues is specially considered due to the existing untapped potential (about four times higher than the installed capacity, considering the current availability of biomass) and the existing window opportunity due to the expansion of sugarcane industry in Brazil (mostly for ethanol production).

12/01227 Thermodynamic analysis of a trigeneration system consisting of a micro gas turbine and a double effect absorption chiller

Huicochea, A. *et al. Applied Thermal Engineering*, 2011, 31, (16), 3347–3353.

Combining heating and power systems represent an option to improve the efficiency of energy usage and to reduce thermal pollution toward environment. Microturbines generate electrical power and usable residual heat which can be partially used to activate a thermally driven chiller. The purpose of this paper is to analyse theoretically the thermodynamic performance of a trigeneration system formed by a microturbine and a double-effect water/LiBr absorption chiller. The heat data supplied to the generator of the double effect air conditioning system was acquired from experimental data of a 28 $\mathrm{kW_E}$ microturbine, obtained at CREVER facilities. A thermodynamic simulator was developed at Centro de Investigación en Energía in the Universidad Nacional Autónoma de México by using a MATLAB programming language. Mass and energy balances of the main components of the cooling system were obtained with water–lithium bromide solution as working fluid. The trigeneration system was evaluated at different operating conditions: ambient temperatures, generation temperatures and microturbine fuel mass flow rate. The results demonstrated that this system represents an attractive technological alternative to use the energy from the microturbine exhaust gases for electric power generation, cooling and heating produced simultaneously.

12/01228 Thermodynamic and exergoenvironmental analyses, and multi-objective optimization of a gas turbine power plant

Ahmadi, P. and Dincer, I. *Applied Thermal Engineering*, 2011, 31, (14–15), 2529–2540.

The present study deals with a comprehensive thermodynamic and exergoeconomic modelling of a gas turbine power plant. In order to validate the thermodynamic model, the results are compared with one of the largest gas turbine power plants in Iran (known as Shahid Salimi gas turbine power plant). Moreover, a multi-objective optimization is performed to find the best design variables. The design parameters considered here are air compressor pressure ratio (r_{AC}), compressor isentropic efficiency (η_{AC}), gas turbine isentropic efficiency (η_{GT}), combustion chamber inlet temperature (T_3) and gas turbine inlet temperature. In the multi-objective optimization approach, certain exergetic, economic and environmental parameters are considered through two objective functions, including the gas turbine exergy efficiency, total cost rate of the system production including cost rate of environmental impact. In addition, fast and effective non-dominated sorting genetic algorithm (NSGA-II) is applied for the optimization purpose. The thermoenviroeconomic objective function is minimized while power plant exergy efficiency is maximized using a power full developed genetic algorithm. The results of optimal designs are obtained as a set of multiple optimum solutions, called 'the Pareto optimal solutions'. Moreover, the optimized results are compared with the working data from the case study. These show that by selecting the optimized data a 50% reduction in environmental impacts is obtained. Finally, sensitivity analysis of change in objective functions, when the optimum design parameters vary, is performed and the degree of each parameter on conflicting objective functions has been determined.

12/01229 27-Level DC–AC inverter with single energy source

Tsang, K. M. and Chan, W. L. *Energy Conversion and Management*, 2012, 53, (1), 99–107.

A novel design of multilevel DC–AC inverter using only single renewable energy source is presented in this paper. The proposed approach enables multilevel output to be realized by a few cascaded H-bridges and a single energy source. As an illustration, a 27-level inverter has been implemented based on three cascaded H-bridges with a single energy source and two capacitors. Using the proposed novel switching strategy, 27 levels can be realized and the two virtual energy sources can be well regulated. Experimental results are included to demonstrate the effectiveness of the proposed inverter.

12/01230 Use of a test-bed to study the performance of micro gas turbines for cogeneration applications

Caresana, F. *et al. Applied Thermal Engineering*, 2011, 31, (16), 3552–3558.

This paper presents the experimental results of a test-bed developed to analyse a 100 kW cogeneration micro gas turbine (MGT). Its main feature, flexibility, allows MGT testing in nearly all the conditions that final use may entail, in particular simulation of operating conditions and thermal loads in broadly different electrical power, flow rate and temperature conditions of the cogeneration circuit. The MGT and its operating modes are described and the test-bed design philosophy is outlined. Finally the methods applied to test the cogeneration plant's performance are described and the experimental results in terms of power, efficiency, primary energy saving index and emissions are reported. In the tests electrical power ranged between 40 and 100 kW; electrical efficiency reached ~29% in the 80–100 kW range. Analysis of the performance of the recovery heat exchanger at different values of inlet and outlet water temperature and flow rate showed that the maximum thermal power recovered was ~160 kW and the maximum PES index was about 24%. With regard to the main pollutants at the exhaust, NO_x concentrations were <6 ppmv in the whole MGT working range, while CO concentrations increased substantially at low electrical power values, starting from around 10 ppmv at nominal load.

Economics, policy, supplies, forecasts

12/01231 A hybrid CPSO–SQP method for economic dispatch considering the valve-point effects

Cai, J. *et al. Energy Conversion and Management*, 2012, 53, (1), 175–181.

This paper developed a new method for solving the economic dispatch (ED) problems considering the valve-point effects in power systems. The method is based on a hybrid algorithm consisting of chaotic particle swarm optimization (CPSO) algorithm and sequential quadratic programming (SQP) techniques. The CPSO is the main optimizer of the algorithm and the SQP is used to fine tune its results to improve the solution. The proposed method was applied to three different cases of power systems. The economic effect, solution quality, convergence property and computation efficiency of the proposed method have been explored through the comparison with the existing techniques for the ED problems considering the valve-point effects. The simulation results demonstrate the applicability and effectiveness of the proposed algorithm to the practical ED problems.

12/01232 A model for micro-trigeneration systems based on linear optimization and the Italian tariff policy

Arosio, S. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2292–2300.

The influence of endogen and exogen variables on the performances of small-scale trigenerative plants is investigated by means of a simulation model where the prime mover and the other components are considered as 'black boxes' characterized by their performance parameters. The operating policy of the plant is not imposed a priori, but it is on the contrary dynamically and automatically chosen by the model itself using linear optimization techniques. The 'constitutive equations' which formalize the relationships between the plant components and the energetic and economic target functions are expressed using linear terms only. By parametrizing the characteristics of the involved machines and of the end users, such a model allows to evaluate the influence of each parameter on the performances of the whole system. The aim is to give useful indications to the manufacturers, designers and end users in the field of trigeneration. The analysis is performed at two different level of details: the first one with a simplified version of the model, for a preliminary evaluation of the influence of the most important parameters, the second one using the complete model, focusing the attention on the Italian situation in terms of tariffs for energy and external temperatures.

12/01233 A novel hybrid approach based on particle swarm optimization and ant colony algorithm to forecast energy demand of Turkey

Kiran, M. S. *et al. Energy Conversion and Management*, 2012, 53, (1), 75–83.

This paper proposes a new hybrid method (HAP) for estimating energy demand of Turkey using particle swarm optimization (PSO) and ant colony optimization (ACO). Proposed energy demand model (HAPE) is the first model which integrates two mentioned meta-heuristic techniques. While, PSO, developed for solving continuous optimization problems, is a population based stochastic technique; ACO, simulating behaviours between nest and food source of real ants, is generally used for discrete optimizations. Hybrid method based PSO and ACO is developed to estimate energy demand using gross domestic product (GDP), population, import and export. HAPE is developed in two forms which are linear (HAPEL) and quadratic (HAPEQ). The future energy demand is estimated under different scenarios. In order to show the accuracy of the algorithm, a comparison is made with ACO and PSO which are developed for the same problem. According to obtained results, relative estimation errors of the HAPE model are the lowest of them and quadratic form (HAPEQ) provides better-fit solutions due to fluctuations of the socio-economic indicators.

12/01234 A seasonal hybrid procedure for electricity demand forecasting in China

Zhu, S. *et al. Applied Energy*, 2011, 88, (11), 3807–3815.

Electricity is a special energy which is hard to store, so the electricity demand forecasting in China remains an important problem. This paper aims at developing an improved hybrid model for electricity demand in China, which takes the advantages of moving average procedure, combined method, hybrid model and adaptive particle swarm optimization algorithm, known as MA-C-WH. It is designed for making trend and seasonal adjustments which simultaneously presents the electricity demand forecasts. Four actual electricity demand time series in China power grids are selected to illustrate the proposed MA-C-WH model, and one existing seasonal autoregressive integrated moving average model (SARIMA) is selected to compare with the proposed model using the same data series. The results of popular forecasting precision indexes show that the proposed model is an effective forecasting technique for seasonal time series with non-linear trend.

12/01235 Allocation of economic costs in trigeneration systems at variable load conditions

Lozano, M. A. *et al. Energy and Buildings*, 2011, 43, (10), 2869–2881.

This paper presents a thermoeconomic analysis of a trigeneration system interacting with the economic environment. The aim is to determine the energy and total costs of internal flows and final energy services (electricity, cooling and heat). One of the main difficulties in calculating these costs in trigeneration plants within buildings is the continuous variation of energy supply services. Fuel prices and purchase/sale electricity tariffs can also vary. As a consequence there are different operation conditions that combine the possibilities of purchasing or selling electricity, consuming heat from auxiliary boilers, and wasting the excess of cogenerated heat. A novel cost allocation method valid for all possible operation conditions of the trigeneration system is proposed. The heat produced by cogeneration modules is disaggregated into three fractions: heat that meets the heat demand directly, heat utilized to drive absorption chillers (producing cooling), and heat dissipated to the environment. Cost allocation to all cogeneration co-products is determined by applying the principle of avoided expenditures. The cost allocation proposal is applied to a trigeneration system providing energy services to a hospital with 500 beds located in Zaragoza (Spain), encouraging rational and efficient energy services production and consumption.

12/01236 An economic analysis model for the energy storage system applied to a distribution substation

Leou, R.-C. *International Journal of Electrical Power & Energy Systems*, 2012, 34, (1), 132–137.

Recent developments and advances in energy storage technologies are making the application of energy storage technologies a viable solution to power applications. The energy storage system can store energy previously, and then release it in the proper time. Due to their flexibility, it is suitable to apply this technology to deregulated power markets. Therefore, this paper will build the economic analysis model for the energy storage system to apply to a distribution substation in a deregulated power market. The costs including installing energy storage system and operation and maintenance expense, and the revenues containing energy price arbitrage, reducing transmission access cost, and deferring facility investment are considered in this model. All these factors are evaluated by present worth value. Due to complexity of this problem, this paper proposes a method combining the genetic algorithm with linear program (GALP) to determine the optimal capacity and operations of the energy storage system.

12/01237 Assessing energy supply security: outage costs in private households

Praktiknjo, A. J. *et al. Energy Policy*, 2011, 39, (12), 7825–7833.

The objective of this paper is to contribute to the topic of energy supply security by proposing a Monte Carlo-based and a survey-based model to analyse the costs of power interruptions. Outage cost estimations are particularly important when deciding on investments to improve supply security (e.g. additional transmission lines) in order to compare costs to benefits. But also other policy decisions on measures that have direct or indirect consequences for the supply security (e.g. a phasing out of nuclear energy) need to be based on results from outage cost estimations. The main focus of this paper lies with residential consumers, but the model is applied to commercial, industrial and governmental consumers as well. There are limited studies that have approached the problem of evaluating outage cost. When comparing the results of these studies, they often display a high degree of diversification. As consumers have different needs and dependencies towards the supply of electricity because of varying circumstances and preferences, a great diversity in outage cost is a logical consequence. To take the high degree of uncertainties into account, a Monte Carlo simulation was conducted in this study for the case of private households in Germany.

12/01238 Biomass assessment and small scale biomass fired electricity generation in the Green Triangle, Australia

Rodriguez, L. C. *et al. Biomass and Bioenergy*, 2011, 35, (7), 2589–2599.

Coal-fired electricity is a major factor in Australia's greenhouse gas emissions (GHG) emissions. The country has adopted a mandatory renewable energy target (MRET) to ensure that 20% of electricity comes from renewable sources by 2020. In order to support the MRET, a market scheme of tradable renewable energy certificates (RECs) has been implemented since 2001. Generators using biomass from eligible sources are able to contribute to GHG emission reduction through the substitution of coal for electricity production and are eligible to create and trade RECs. This paper quantifies the potential biomass resources available for energy generation from forestry and agriculture in the Green Triangle, one of the most promising Australian Regions for biomass production. The cost of electricity generation is analysed using direct firing of biomass, and estimate the required REC prices to make it competitive with coal-fired electricity generation. Major findings suggest that more than 2.6 million tonnes of biomass are produced every year within 200 km of the regional hub of Mount Gambier and biomass-fired electricity is viable using feedstock with a plant gate cost of A$46 per tonne under the current REC price of A$34 per MWh. These findings are then discussed in the context of regional energy security and existing targets and incentives for renewable energies.

12/01239 Comparing the feed-in tariff incentives for renewable electricity in Ontario and Germany

Mabee, W. E. *et al. Energy Policy*, 2012, 40, 480–489.

The development of feed-in tariff (FIT) programs to support green electricity in Ontario (the Green Energy and Green Economy Act of 2009) and Germany (the Erneuerbare Energien-Gesetz of 2000) is compared. The two policies are highly comparable, offering similar rates for most renewable electricity technologies. Major differences between the policies include the level of differentiation found in the German policy, as well as the use of a price digression strategy for FIT rates in Germany compared to an escalation strategy in Ontario. The German renewable electricity portfolio is relatively balanced, compared to Ontario where wind power dominates the portfolio. At the federal level, Canada does not yet have a policy similar to the European directive on renewable energy, and this lack may impact decisions taken by manufacturers of renewable technologies who consider establishing operations in the province. Ontario's Green Energy and Green Economy Act could be benefit from lessons in the German system, especially with regard to digression of feed-in tariff rates over time, which could significantly reduce payments to producers over the course of a contract, and in turn encourage greater competitiveness among renewable power providers in the future.

12/01240 Current phase comparison pilot scheme for distributed generation networks protection

El Halabi, N. *et al. Applied Energy*, 2011, 88, (12), 4563–4569.

The trends of the actual distribution networks are moving toward a high penetration of distributed generation and power electronics converters. These technologies modify contribution-to-fault current magnitudes and raise concern about new protection parameters settings to accurately detect faults on distribution networks. This paper proposes a differential phase jump pilot scheme to detect faulted branches in distribution networks. The aim of the proposed scheme is to provide an efficient algorithm with functions of fault detection and isolation, which are part of the self-healing functions used for smart grids. The proposed scheme is based on the current phase jump measured in each node with fault inception. Then, by comparing the phase jump obtained with the prefault conditions and rate changes, it determines the fault direction enabling a trip signal to the corresponding nodes to isolate the branch under fault. A distribution network has been modelled in PSCAD/EMTDC program to verify the proposed algorithm, taking into account distributed generation provided by both wind turbines (doubly fed induction generator and permanent magnet generator with full converter) and solar photovoltaic installations. The behaviour of the current phase jump has been studied for both generation and load nodes. This algorithm is not affected by the magnitude of current and voltage and has been tested varying fault location and resistance along the modelled distribution network.

12/01241 Economic feasibility assessment of rice straw utilization for electricity generating through combustion in Thailand

Delivand, M. K. *et al. Applied Energy*, 2011, 88, (11), 3651–3658.

The economic feasibility of biomass based combustion projects of various capacities to generate electricity from rice straw is evaluated for Thailand. For an assumed lifespan of 20 years, rice straw-fuelled combustion facilities would generate net present values (NPV) of −3.15, 0.94, 2.96, 9.33, and 18.79 million USD for projected 5, 8, 10, 15, and 20 $\mathrm{MW_e}$ plants, respectively. Examining the effects of scale on the cost of generated electricity (COE) over the considered range of capacities indicates that COE varies from 0.0676 USD/kWh at 20 $\mathrm{MW_e}$ to 0.0899 USD/kWh at 5 $\mathrm{MW_e}$. By scaling up the power plants, the variations of the financial parameters, namely NPV values, become less sensitive to the critical variables. As an example, if the fuel price, selling price of electricity, and the plant factor change by +36% (31.0 USD/t), −16% (0.0758 USD/kWh), and −14% (5650 h/year), respectively, the largest scale project is still appealing for investment. Nevertheless, to ensure a secure fuel supply, smaller scale power plants, i.e. 8 and 10 $\mathrm{MW_e}$ may be more practicable. A further sensitivity analysis is discussed in terms of the financial feasibility of the projects (i.e. $\mathrm{NPV} \geq 0$), and the investment appraisal condition (here, internal rate of return ≥ 11%).

12/01242 Electric load forecasting by seasonal recurrent SVR (support vector regression) with chaotic artificial bee colony algorithm

Hong, W.-C. *Energy*, 2011, 36, (9), 5568–5578.

Support vector regression (SVR), with hybrid chaotic sequence and evolutionary algorithms to determine suitable values of its three parameters, not only can effectively avoid converging prematurely (i.e. trapping into a local optimum), but also reveals its superior forecasting performance. Electric load sometimes demonstrates a seasonal (cyclic) tendency due to economic activities or climate cyclic nature. The applications of SVR models to deal with seasonal (cyclic) electric load forecasting have not been widely explored. In addition, the concept of recurrent neural networks (RNNs), focused on using past information to capture detailed information, is helpful to be combined into an SVR model. This investigation presents an electric load forecasting model which combines the seasonal recurrent support vector regression model with chaotic artificial bee colony algorithm (namely SRSVRCABC) to improve the forecasting performance. The proposed SRSVRCABC employs the chaotic behaviour of honey bees which is with better performance in function optimization to overcome premature local optimum. A numerical example from an existed reference is used to elucidate the forecasting performance of the proposed SRSVRCABC model. The forecasting results indicate that the proposed model yields more accurate forecasting results than ARIMA and TF-ε-SVR-SA models. Therefore, the SRSVRCABC model is a promising alternative for electric load forecasting.

12/01243 Electricity capacity investment under risk aversion: a case study of coal, gas, and concentrated solar power

Fan, L. *et al. Energy Economics*, 2012, 34, (1), 54–61.

The policy instrument many economists favour to reduce greenhouse gas emissions and to shift new investment towards low carbon technologies is the tradable allowance system. Experience with this instrument has been mixed, with a crucial design issue being the choice of whether to auction allowances to firms, or to grandfather them based on historical emissions. In this paper, the changing incentives of investment in different technologies are examined, when investors are risk averse and are expecting an allowance system with a certain allocation rule but do not know if the policy is going to take place in the near future. Investors also cannot fully predict future investment costs for the low-carbon technology. A game theoretic model is applied to examine the combined effects of uncertainty and risk aversion on the actions of potential investors into high and low carbon generating capacity, under both allocation rules and uncertain costs. It is found that that uncertainty and risk aversion do have implications towards investment incentives. Policy implications of these findings are discussed.

12/01244 Electricity consumption and real GDP causality nexus: evidence from ARDL bounds testing approach for 11 MENA countries

Ozturk, I. and Acaravci, A. *Applied Energy*, 2011, 88, (8), 2885–2892.

This paper investigates the short-run and long-run causality issues between electricity consumption and economic growth in the selected 11 Middle East and north Africa (MENA) countries by using autoregressive distributed lag (ARDL) bounds testing approach of cointegration and vector error-correction models. It employs annual data covering the period from 1971 to 2006. The unit root tests results indicate that some of the variables for Algeria, Jordan, Tunisia and United Arab Emirates do not satisfy the underlying assumptions of the ARDL bounds testing approach of cointegration methodology before proceeding to the estimation stage. Thus, these countries are omitted from the ARDL bounds testing approach of cointegration and causality analysis. The cointegration test results show that there is no cointegration between the electricity consumption and the economic growth in three of the seven countries (Iran, Morocco and Syria). Thus, causal relationship cannot be estimated for these countries. However, the cointegration and causal relationship is found in four countries (Egypt, Israel, Oman and Saudi Arabia). The overall results indicate that there is no relationship between the electricity consumption and the economic growth in most of the MENA countries. Further evidence indicates that policies for energy conservation can have a little or no impact on economic growth in most of the MENA countries.

12/01245 Electricity market auction settings in a future Danish electricity system with a high penetration of renewable energy sources – a comparison of marginal pricing and pay-as-bid

Nielsen, S. *et al. Energy*, 2011, 36, (7), 4434–4444.

The long-term goal for Danish energy policy is to be free of fossil fuels through the increasing use of renewable energy sources (RES) including fluctuating renewable electricity (FRE). The Danish electricity market is part of the Nordic power exchange, which uses a marginal price auction system (MPS) for the day-ahead auctions. The market price is thus equal to the bidding price of the most expensive auction winning unit. In the MPS, the FRE bid at prices of or close to zero resulting in reduced market prices during hours of FRE production. In turn, this reduces the FRE sources' income from market sales. As more FRE is implemented, this effect will only become greater, thereby reducing the income for FRE producers. Other auction settings could potentially help to reduce this problem. One candidate is the pay-as-bid auction setting (PAB), where winning units are paid their own bidding price. This article investigates the two auction settings, to find whether a change of auction setting would provide a more suitable frame for large shares of FRE. This has been done with two energy system scenarios with different shares of FRE. From the analysis, it is found that MPS is generally better for the FRE sources. The result is, however, very sensitive to the base assumptions used for the calculations.

12/01246 Exergy based performance analysis of high efficiency poly-generation systems for sustainable building applications

Bingöl, E. *et al. Energy and Buildings*, 2011, 43, (11), 3074–3081.

In this study, first and second laws of thermodynamics, accompanying with rational exergy management method (REMM) were employed in developing a MATLAB-based algorithm for natural gas-fired, internal combustion engine (ICE) driven poly-generation systems. Two systems were studied based on a tri-generation plant built within the framework of the EU-FP6 HEGEL Project, tested at METU MATPUM (RICBED) building. This study introduces a better set of metrics for rating, evaluating, and optimizing poly-generation systems in order to minimize emissions, maximize fuel savings, and thus to accomplish an optimum sustainability metric among the factors of environment, energy, human needs and economics. Results show that with ICE poly-generation systems, exergy efficiency may increase beyond 60%. Even at part loads, minimum values of primary energy savings (PES) are 12.4% for case-1 and 17.7% for case-2 (compared to minimum allowed 10%). REMM efficiency and exergy embedded PES (PES_R) evaluated by REMM are proven to be better indicators of the performance. When exergy destruction is lower (waste heat is recovered), PES_R increases significantly. PES_R values are minimum 18.2% for case-1 and 42.4% for case-2, which reveals that both systems provide high-performance energy generation and considerably lower emissions.

12/01247 Forecasting hourly electricity prices using ARMAX–GARCH models: an application to MISO hubs

Hickey, E. *et al. Energy Economics*, 2012, 34, (1), 307–315.

The recent deregulation of the electricity industry and reliance on competitive wholesale markets has generated significant volatility in wholesale electricity prices. Given the importance of short-term price forecasts in this new environment, this paper estimates and evaluates the forecasting performance of four ARMAX–GARCH models for five MISO pricing hubs (Cinergy, First Energy, Illinois, Michigan, and Minnesota) using hourly data from 1 June 2006 to 6 October 2007. The empirical results reveal three important patterns: (a) electricity price volatility is regional and the optimum volatility model depends in part on the hub location, the forecast horizon, and regulated versus unregulated status of the market; (b) the APARCH model performs well in hubs in deregulated states; and (c) volatility dynamics in regulated states are better captured by a simple GARCH model and thus are less complex.

12/01248 How much should we pay for interconnecting electricity markets? A real options approach

Cartea, Á. *et al. Energy Economics*, 2012, 34, (1), 14–30.

An interconnector is an asset that gives the owner the option to transmit electricity between two locations. In financial terms, the value of an interconnector is the same as a strip of real options written on the spread between power prices in two markets. The authors model the spread based on a seasonal trend, mean-reverting Gaussian process, and mean-reverting jump process and express the value of these real options in closed-form. The valuation tool is applied to five pairs of European neighbouring markets to value a hypothetical 1-year lease of the interconnector using different assumptions about the seasonal component of the spread, and different liquidity caps which proxy for the depth of the interconnected power markets. The authors derive no-arbitrage lower bounds for the value of the interconnector in terms of electricity futures contract and find that, depending on the depth of the market, the jumps in the spread can account for between 1% and 40% of the total value of the interconnector. The two markets where an interconnector would be most (respectively least) valuable are Germany and The Netherlands (respectively France and Germany). Finally, rules of thumb are provided to interpret the different interconnector values.

12/01249 Possibilistic programming approach for mid-term electric power planning in deregulated markets

Lotfi, M. M. and Ghaderi, S. F. *International Journal of Electrical Power & Energy Systems*, 2012, 34, (1), 161–170.

The mid-term electric power planning problem under uncertainty for a generation company (GenCo) in a deregulated market having some thermal, hydro and wind power plants is addressed. The authors propose a novel possibilistic price-based mixed integer linear programming approach to solve the considered problem. Because the uncertainties especially those are related to market could not usually be based on probabilities, the possibilistic distribution functions are used to simulate some key imprecise/ambiguous parameters: GenCo's electricity market share; electricity, fuel and emission market prices; possible wind electric power; availability of generating units; available water reservoir for hydro units. To solve the proposed model, an interactive possibilistic solution method is developed based on two recent solution approaches. Finally, a real-world case study is used to show the ability and appropriateness of the model and report computational results. Notably, the proposed approach can be easily applied for a regulated environment.

12/01250 Power sector investment risk and renewable energy: a Japanese case study using portfolio risk optimization method

Bhattacharya, A. and Kojima, S. *Energy Policy*, 2012, 40, 69–80.

The conventional pricing mechanism used for electricity systematically hides huge investment risks which are embedded in the overall cost of production. Although consumers are often unaware of these risks, they present a large financial burden on the economy. This study applies the portfolio optimization concepts from the field of finance to demonstrate the scope of greater utilization of renewable energies while reducing the embedded investment risk in the conventional electricity sector and its related financial burden. This study demonstrates that RE investment can compensate for the risks associated with the total input costs; such costs being external volatilities of fossil fuel prices, capital costs, operating and maintenance costs and the carbon costs. By means of example, this case study shows that Japan could in theory obtain up to 9% of its electricity supply from green sources, as compared to the present 1.37%, based on the utilization of a portfolio risk-analysis evaluation. Explicit comparison of the monetary values of the investment risks of conventional and renewable energy sources shows that renewable energies have high market competitiveness. The study concludes with a recommendation that, as a business objective, investors would benefit by focusing on electricity supply portfolio risk minimization instead of cost. This could also inherently increase the supply of renewable energy in the market.

12/01251 Reactive power market management considering voltage control area reserve and system security

Kargarian, A. *et al. Applied Energy*, 2011, 88, (11), 3832–3840.

This paper presents a new algorithm to optimize reactive power procurement through commercial transactions considering system voltage security. The proposed algorithm minimizes reactive power provision and transmission loss costs in addition to maximizing system voltage security margin through a multiobjective function. In order to maintain the voltage profile of power system during sever contingencies or due to load uncertainty, all voltage control areas (VCA) of the system are detected and then optimal reactive power reserve is provided for each VCA during the market settlement. A four-stage multiobjective mathematical programming method is proposed to settle the reactive power market. The proposed algorithm has been applied on IEEE-RTS test system. The simulation results show the effectiveness of the proposed algorithm for reactive power market management.

12/01252 Retailers' risk management and vertical arrangements in electricity markets

Boroumand, R. H. and Zachmann, G. *Energy Policy*, 2012, 40, 465–472.

The failure of the asset-light retailer's organizational model is indicative of the incapacity of this organizational structure to manage efficiently the combination of sourcing and market risks in the current market environment. Because of the structural dimensions of electricity's market risks, a retailer's level of risk exposure is unknown *ex ante* and will only be revealed *ex post* when consumption is known. In contrast to the 'textbook model' of electricity reforms, the paper demonstrates through numerical simulations that in the current market context pure portfolios of contracts are incomplete risk management instruments compared to physical hedging. The latter is critical to overcome the asset-light retailer's curse.

12/01253 Security of electricity supply at the generation level: problem analysis

Rodilla, P. and Batlle, C. *Energy Policy*, 2012, 40, 177–185.

Since the very beginning of the restructuring process, back in 1982 in Chile, the ability of an electricity market to provide the system with the required level of security of supply has been put into question. The mistrust on the ability of the market, left to its own devices, to provide sufficient generation availability when needed, is more and more leading to the implementation of additional regulatory mechanisms. This matter is undoubtedly gaining importance and it has taken a key role in the energy regulators' agendas. In this paper, the authors revisit this discussion under the light of 30 years of electricity market experience. The different reasons why are analysed, although ideally the market is supposed to provide itself an adequate security of supply at the generation level, this result is still far from being achieved in practice.

12/01254 South Africa's electricity consumption: a sectoral decomposition analysis

Inglesi-Lotz, R. and Blignaut, J. N. *Applied Energy*, 2011, 88, (12), 4779–4784.

South Africa's electricity consumption has shown a sharp increase since the early 1990s. Here, a sectoral decomposition analysis is conducted of the electricity consumption for the period 1993–2006 to determine the main drivers responsible for this increase. The results show that the increase was mainly due to output or production related factors, with structural changes playing a secondary role. While there is some evidence of efficiency improvements, indicated here as a slowdown in the rate of increase of electricity intensity, it was not nearly sufficient to offset the combined production and structural effects that propelled electricity consumption forward. This general economy-wide statement, however, can be misleading since the results, in essence, are very sector specific and the inter-sectoral differences are substantial. Increases in production were proven to be part of the rising trend for all sectors. However, only five out of fourteen sectors were affected by efficiency improvements, while the structural changes affected the sectors' electricity consumption in different ways. These differences concerning the production, structural and efficiency effects on the sectors indicate the need for a sectoral approach in the energy policy-making of the country rather than a blanket or unilateral economy-wide approach.

12/01255 Structural vulnerability of power systems: a topological approach

Bompard, E. *et al. Electric Power Systems Research*, 2011, 81, (7), 1334–1340.

Vulnerability analysis of power systems is a key issue in modern society and many efforts have contributed to the analysis. Complex network metrics for the assessment of the vulnerability of networked systems have been recently applied to power systems. Complex network theory may come in handy for vulnerability analysis of power systems due to a close link between the topological structure and physical properties of power systems. However, a pure topological approach fails to capture the engineering features of power systems. So an extended topological method has been proposed by incorporating several of specific features of power systems such as electrical distance, power transfer distribution factors and line flow limits. This paper defines, starting from the extended metric for efficiency named as net-ability, an extended betweenness and proposes a joint method of extended betweenness and net-ability to rank the most critical lines and buses in an electrical power grid. The method is illustrated in the IEEE-118-bus, IEEE-300-bus test systems as well as the Italian power grid.

12/01256 Technical and economic analysis of electricity generation from forest, fossil, and wood-waste fuels in a Finnish heating plant

Palander, T. *Energy*, 2011, 36, (9), 5579–5590.

The Finnish energy industry is subject to policy decisions regarding renewable energy production and energy efficiency. Conventional electricity generation has environmental side-effects that may cause global warming. Renewable fuels are superior because they offer near-zero net emissions. In this study, the author investigated a heating mill's ability to generate electricity from forest fuels in southern Finland on a 1-year strategic decision-making horizon. The electricity generation problem was solved using optimization of the energy products and fuel mixtures based on energy efficiency and forest technology. The decision environment was complicated by the sequence-dependent procurement chains for forest fuels. The optimal product and fuel mixtures were selected by minimizing procurement costs, maximizing production revenues, and minimizing energy losses. The combinatorial complexity of the problem required the use of adaptive techniques to solve a multiple-objective linear programming system with industrial relevance. The properties of the decision-support system and methodology are discussed and pricing of electricity generation based on real industrial data is illustrated. The electricity generation, purchase, and sales decisions are made based on a comprehensive technical and economic analysis that accounts for procurement of local forest fuels in a holistic supply chain model.

12/01257 The importance of market interdependencies in modeling energy systems – the case of the European electricity generation market

Lienert, M. and Lochner, S. *International Journal of Electrical Power & Energy Systems*, 2012, 34, (1), 99–113.

The analysis of complex electricity generation systems such as the European one require large-scale models based on extensive databases of the relevant infrastructures. Such models are increasingly used to assist policymaking by developing scenarios to investigate the impact of certain policies on generation capacities, investments and prices. The continuing liberalization and interconnection of energy markets thereby requires the considerations of multiple interdependencies with other markets. Most models, however, do not take this into account. This paper develops and applies a large scale electricity investments and dispatch and natural gas market dispatch model to highlight the importance of recognizing interdependencies between power generation and the gas market. In an exemplary analysis, it is demonstrated that seasonal gas price patterns resulting from temperature-dependent household gas demand have a significant impact on the competitiveness of gas-fired power stations in competition with other technologies. Spatially, it is shown that competitive cost-based gas prices would lead to a relocation of such plants closer to the sources of natural gas.

12/01258 The inevitability of capacity underinvestment in competitive electricity markets

Milstein, I. and Tishler, A. *Energy Economics*, 2012, 34, (1), 62–77.

Very tight generation capacity ('underinvestment') in competitive electricity markets is a major concern to policy-makers. Employing a model with endogenous capacity, capacity mix, operations and with uncertain demand it is shown that 'underinvestment' is due to the rational (non-abusive) behaviour of profit-seeking producers and other market participants. Instead of building new capacity that will be idle during most of the year, electricity producers let the electricity price spike (price spikes 'substitute' for capacity). These results hold true when each electricity producer is allowed to construct and operate only one (base or peaking) generation technology or both, although capacity mix, industry profits and consumer surplus may differ substantially between these two market structures. The authors also show, for both market structures, how CO_2 taxes affect consumer surplus and the industry's optimal capacity, capacity mix and profits, and demonstrate that total welfare gains from the CO_2 tax may be substantial. Finally, the authors supply the regulator with easy-to-use tools to decide which market structure is to be preferred in terms of social welfare.

12/01259 UK scenario of islanded operation of active distribution networks with renewable distributed generators

Chowdhury, S. P. *et al. International Journal of Electrical Power & Energy Systems*, 2011, 33, (7), 1251–1255.

This paper reports on the current UK scenario of islanded operation of active distribution networks with renewable distributed generators (RDGs). Different surveys indicate that the present scenario does not economically justify islanding operation of active distribution networks with RDGs. With rising DG penetration, much benefit would be lost if the DGs are not allowed to island only due to conventional operational requirement of utilities. Technical studies clearly indicate the need to review parts of the electricity safety, quality and continuity regulations for successful islanded operations. Commercial viability of islanding operation must be assessed in relation to enhancement of power quality, system reliability and supply of potential ancillary services through network support. Demonstration projects under registered power zone and technical architecture projects should be initiated to investigate the utility of distributed generator islanding. However these efforts should be compounded with a realistic judgement of the associated technical and economic issues for the development of future power networks beyond 2010.

12/01260 Understanding the design and economics of distributed tri-generation systems for home and neighborhood refueling – Part II: neighborhood system case studies

Li, X. and Ogden, J. M. *Journal of Power Sources*, 2012, 197, 186–195.

The lack of a hydrogen infrastructure remains a major barrier for fuel cell vehicle (FCV) adoption. The high cost of an extensive hydrogen station network and the low utilization in the near term discourage private investment. Past experience of fuel infrastructure development for motor vehicles, indicates that innovative, distributed, small-volume hydrogen refuelling methods may be required to refuel FCVs in the near term. Among small-volume refuelling methods, home and neighbourhood tri-generation systems stand out because the technology is available and has potential to alleviate consumer's fuel availability concerns. Additionally, it has features attractive to consumers such as convenience and security to refuel at home or in their neighbourhood. In this paper, the authors study neighbourhood tri-generation systems in multi-unit dwellings such as apartment complexes. The authors apply analytical tools including an interdisciplinary framework and an engineering/economic model to a representative multi-family residence in the northern California area. The simulation results indicate that a neighbourhood tri-generation system improves the economics of providing the three energy products for the households compared with the two alternatives studied. The small capacity of the systems and the valuable co-products help address the low utilization problem of hydrogen infrastructure.

12/01261 Using phasor data records and sequence of events to automate the classification of disturbances of power generating units

Moreto, M. and Rolim, J. G. *Electric Power Systems Research*, 2011, 81, (7), 1266–1273.

Nowadays, it is a common practice in power generation utilities to monitor the generation units using digital fault recorders (DFRs). As the disturbance records are in general, analysed and stored at the central office or control centre, it has become difficult for engineers to analyse all this data. This paper presents a preprocessing methodology that automatically analyses and classifies each record into known categories, focusing the engineer's attention to the most relevant occurrences. The scheme uses phasor records from DFR and the sequence of events (SOE) to achieve this. The data is pre-processed and then submitted to a set of expert systems in order to conclude the cause of the occurrence. Hundreds of real disturbance records and their corresponding SOE were used to evaluate the proposed scheme. The results show that about 95% of the records do not need further analysis and can be automatically stored without human intervention. The scheme is important in order to reduce the time spent with the disturbance analysis.

07 STEAM RAISING

Boiler operation/design

12/01262 Availability analysis of heat recovery steam generators used in thermal power plants

Carazas, F. J. G. *et al. Energy*, 2011, 36, (6), 3855–3870.

The combined-cycle gas and steam turbine power plant presents three main pieces of equipment: gas turbines, steam turbines and heat recovery steam generator (HRSG). In case of HRSG failure the steam cycle is shut down, reducing the power plant output. Considering that the technology for design, construction and operation of high capacity HRSGs is quite recent its availability should be carefully evaluated in order to foresee the performance of the power plant. This study presents a method for reliability and availability evaluation of HRSGs installed in combined-cycle power plant. The method's first step consists in the elaboration of the steam generator functional tree and development of failure mode and effects analysis. The next step involves a reliability and availability analysis based on the time to failure and time to repair data recorded during the steam generator operation. The third step, aiming at availability improvement, recommends the fault-tree analysis development to identify components the failure (or combination of failures) of which can cause the HRSG shutdown. Those components maintenance policy can be improved through the use of reliability centred maintenance concepts. The method is applied on the analysis of two HRSGs installed in a 500 MW combined-cycle power plant.

12/01263 Investing in efficient industrial boiler systems in China and Vietnam

Yang, M. and Dixon, R. K. *Energy Policy*, 2012, 40, 432–437.

Energy efficiency in industrial boiler steam systems can be very low due to old technologies, improper design and non-optimal operation of the steam systems. Solutions include efficiency assessments and investments in steam system optimizations, education and training for operators of the systems. This paper presents case studies on assessing and investing in boiler steam systems in China and Vietnam. Methodologies and approaches for data collection and analyses were designed specifically for each of the two countries. This paper concludes: (1) investing in energy efficiency in industrial boiler steam system in China and Vietnam are cost effective; (2) government should not sent national energy efficiency standards lower than that of energy companies or energy equipment manufactures.

12/01264 Numerical study on annular tube once-through steam generator using compressible flow model

Wang, Z. L. *et al. Annals of Nuclear Energy*, 2012, 39, (1), 49–55.

The once-through steam generator is an essential component of the integrated nuclear power system. A compressible model with fixed boundaries was applied to study the thermo-hydraulic characteristics of an annular tube once-through steam generator. The present model follows the three fundamental conservation principles in the lumped parameters form, and adopts special method for the primary flow distribution in the annular tube. The Gear algorithm is adopted to solve the differential equations. The steady-state and transient results show that the proposed model can successfully simulate the transient processes with large disturbances in the steam generator. Comparisons between the compressible and incompressible flow models indicate that the compressible flow model is necessary to the steam generator transient simulation.

12/01265 Primary fluid optimization in once-through steam generator

Wei, X. *et al. Applied Thermal Engineering*, 2011, 31, (17–18), 3979–3988.

The once-through steam generator (OTSG) is widely used in nuclear reactor system due to its advantages of compactness. This paper presents a double-tube OTSG consisting of an outer straight tube and an inner helical tube. In the double-tube, the primary fluid is divided into two parts: one is in the inner tube and the other is in the shell side. This bi-channel flow brings difficulties in optimizing the flow distribution ratio of the primary water (FDRP), and affects the heat transfer and flow characteristics. In this paper, a non-linear constrained optimization method was proposed to optimize the FDRP for keeping balance between maximizing the heat transfer rate and minimizing the pressure drop. A throttling device at the inlet of the lower pressure drop side is introduced to achieve the optimum FDRP. The theoretical analysis and analytical results show that the proposed method can be used in engineering practice for optimizing the primary flow.

12/01266 Steam drum level dynamics in a multiple loop natural circulation system of a pressure-tube type boiling water reactor

Jain, V. *et al. Annals of Nuclear Energy*, 2011, 38, (10), 2227–2237.

Advanced heavy water reactor (AHWR) is a pressure tube type boiling water reactor employing natural circulation as the mode of heat removal under all the operating conditions. Main heat transport system (MHTS) of AHWR is essentially a multi-loop natural circulation system with all the loops connected to each other. Each loop of MHTS has a steam drum that provides for gravity based steam–water separation. Steam drum level is a very critical parameter especially in multi-loop natural circulation systems as large departures from the set point may lead to ineffective separation of steam–water or may affect the driving head. However, such a system is susceptible to steam drum level anomalies under postulated asymmetrical operating conditions among the different quadrants of the core like feedwater flow distribution anomaly among the steam drums or power anomaly among the core quadrants. Analyses were carried out to probe such scenarios and unravel the underlying dynamics of steam drum level using system code RELAP5/Mod3.2. In addition, a scheme to obviate such problem in a passive manner without dependence on level controller was examined. It was concluded that steam drums need to be connected in the liquid as well as steam space to make the system tolerant to asymmetrical operating conditions.

12/01267 Techno-economic analysis of a coal-fired CHP based combined heating system with gas-fired boilers for peak load compensation

Wang, H.-C. *et al. Energy Policy*, 2011, 39, (12), 7950–7962.

Combined heat and power (CHP) plants dominate the heating market in China. With the on-going energy structure reformation and increasing environmental concerns, the authors propose gas-fired boilers to be deployed in underperforming heating substations of heating networks for peak load compensation, in order to improve both energy efficiency and environmental sustainability. However, due to the relatively high price of gas, techno-economic analysis is required for evaluating different combined heating scenarios, characterized by basic heat load ratio (β). Therefore, the dynamic economics and annual cost method is used to develop a techno-economic model for computing the net heating cost of the system, considering the current state of the art of cogeneration systems in China. The net heating cost is defined as the investment costs and operations costs of the system subtracted by revenues from power generation. The model is demonstrated in a real-life combined heating system of Daqing, China. The results show that the minimum net heating cost can be realized at $\beta = 0.75$ with a cost reduction of 16.8% compared to coal heating alone. Since fuel cost is the dominating factor, sensitivity analyses on coal and gas prices are discussed subsequently.

12/01268 Thermal hydraulic performance analysis of a double tube bundle steam generator for a liquid metal reactor

Kim, E.-K. and Baek, B.-J. *Annals of Nuclear Energy*, 2011, 38, (12), 2625–2633.

In this study, thermal–hydraulic performance of a double tube bundle steam generator (DTBSG) using helically coiled tubes was analysed numerically. For this purpose a one-dimensional thermal-hydraulic analysis computer program was developed. The DTBSG contains hot fluid and cold fluid tube bundles, a medium fluid and a pump for a medium fluid circulation in an SG. Heat is transferred from the hot side to the cold side through a medium fluid which fills the SG shell side. The fluids of the hot, cold and medium side are sodium, water/steam, lead–bismuth respectively. The assessment was made for four different types of the DTBSG at 200 MWt. It showed there is an optimum medium flow rate for each type and the separated bundle type have the best heat transfer efficiency (heat transfer rate per unit area) among the various DTBSG. However, it requires quite a large pumping power and the velocity of the medium fluid. The effect of a medium flow rate change is relatively small in the integrated bundle types while it is very large in the separated type. The developed program can be used for the optimum thermal design of a double tube bundle steam generator, which is one of the candidates for an intermediate heat transport system simplification concept.

08 COMBUSTION

Burners, combustion systems

12/01269 A comparison of Raman signatures and laser-induced incandescence with direct numerical simulation of soot growth in non-premixed ethylene/air flames

Herdman, J. D. *et al. Carbon*, 2011, 49, (15), 5298–5311.

The predictions of 'soot' concentrations from numerical simulations for nitrogen-diluted, ethylene/air flames are compared with laser-induced incandescence and Raman spectra observed from samples thermophoretically extracted using a rapid insertion technique. In some flame regions, the Raman spectra were obscured by intense, radiation that appeared to peak in the near infrared spectral region. There is a good agreement between spatial profiles of this *ex situ* laser-induced incandescence (ES-LII) and the 'traditional' in situ laser-induced incandescence (IS-LII). Raman signatures were observed from low in the flame and extended into the upper flame regions. The spectra consisted of overlapping bands between 1000 and 2000 cm^{-1} dominated by the '*G*' band, near ≈ $12/\mathrm{cm}^{-1}$, and the '*D*' band in the upper 1300 cm^{-1} range. Several routines are explored to deconvolve the data including 3- and 5-band models, as well as a 2-band Breit–Wigner–Fano (BWF) model. Because the Raman signals were observed at heights below those where in situ LII was observed, the authors postulate that these signals may be attributable to smaller particles. The results suggest that the observed Raman signals are attributable to particulate with modest (≈1 nm) crystallite sizes. This observation is discussed in the context of current models for nascent particle formation.

12/01270 A multi-zone self-similar chemistry tabulation with application to auto-ignition including cool-flames effects

Ribert, G. *et al. Fuel*, 2012, 91, (1), 87–92.

Chemistry tabulation has been widely used in the literature to introduce some of the major subtleties of detailed chemistry in turbulent flame simulations. In the case of combustion systems featuring numerous degrees of freedom – such as progress of reaction, equivalence ratio, pressure, enthalpy, dilution by burnt gases – the rapidly growing size of the lookup-table file becomes one of the factor limiting chemistry introduction in high performance computing, because the database needs to be loaded on every processor whose memory is limited. A multi-zone self-similar chemistry tabulation technique is proposed to overcome this limitation, in both the cool-flame and the high-temperature flame regimes. A formalism is first developed for seeking self-similar behaviour in auto-ignition. The resulting tabulation strategy is limited to the storage of a few profiles, to which algebraic relations are added. In the case of auto-igniting mixture, it is shown that major species of *n*-heptane–air and methane–air combustion can be captured by a single-set of self-similar profiles, opening perspectives for chemistry tabulation of multi-component liquid fuels.

12/01271 A novel water heater using injected hydrogen combustion exhaust

Toja-Silva, F. *Energy and Buildings*, 2011, 43, (9), 2320–2328.

With the aim of mitigating the necessity of water storage when using electric heaters and the losses and pollutant emissions produced by natural gas heaters, this article proposes a water heater based on a gas turbine system, fed with hydrogen and oxygen obtained by electrolysis within the same unit. By applying a thermodynamic analysis to the whole process, a global energy efficiency of 100% can be obtained. This high efficiency makes sense because the electrolysis losses occur in the form of heat losses, which can be used by the cold water. Because the potential of the electrolysis increases, the heat generation due to the electrolysis heat losses increases and, although the electrolysis efficiency is reduced, the global energy efficiency of the water heater remains at 100%. However, the increase in the electrolysis potential also reduces the response speed of the heater, because of the switch in both convection and conduction heat transfer. Convection heat transfer takes place when the combustion exhaust is injected directly in the cold water flow, downstream of the turbine, avoiding the losses associated with a heat exchanger and a high-temperature exhaust. The electrolysis heat losses are transferred to the water by conduction through the electrolyser walls.

12/01272 A review of progress in heat recirculating meso-scale combustors

Shirsat, V. and Gupta, A. K. *Applied Energy*, 2011, 88, (12), 4294–4309.

Within the past decade there has been a fair amount of interest in utilizing the high energy densities of hydrocarbon fuels at the small scale. The motivation for this is primarily twofold. The first application involves the generation of electricity via the heat released by combustion, in the second application chemical micro-thrusters would provide milli-Newton and micro-Newton levels of thrust for Divert and Attitude Control on the next generation of micro-satellites and micro-aerial vehicles. With this in mind many schemes addressing the fundamental thermal challenges associated with small-scale combustion have been proposed, analysed, and tested. This review will focus on experimental work that has been conducted on heat-recirculating 'Swiss-Roll' combustors and the impact of geometry, materials, catalysts, and scale on the thermal performance, extinction criteria/extinction regimes, and flame dynamics. Additionally, an overview of meso-scale power systems is provided covering both propulsion and electric power generation.

12/01273 Active control of jet premixed flames in a model combustor with manipulation of large-scale vortical structures and mixing

Saiki, Y. *et al. Combustion and Flame*, 2011, 158, (7), 1391–1403.

Active control of a bluff-body stabilized methane/air jet flame issued from a coaxial nozzle is made by using miniature magnetic flap actuators attached to the outer nozzle. CH radical chemiluminescence, and CO and NO_x emissions are measured to assess the flame characteristics. By changing the flapping Strouhal number, the flame stability and CO emission are drastically improved under different equivalence ratio (ϕ) conditions. At $\phi = 0.72$, the optimum Strouhal number for stable combustion is unity, since methane/air mixing is enhanced by large-scale vortices synchronized with the flap motion. On the other hand, at a lower equivalence ratio of $\phi = 0.48$, the optimum Strouhal number is much larger than unity; with small-scale vortices, the premixed combustion is stabilized by stratified mixing. In addition to acetone and OH-PLIF, a new two-line OH-PLIF is employed for flame temperature measurement. The longitudinal flame temperature distribution is obtained from conditional-averaged OH fluorescence intensities at the OH front taken with two different excitation lines. CO and NO_x emission characteristics of the controlled flame are discussed on the basis of the local fuel and OH distributions and the flame temperature.

12/01274 Behavior of PAHs and PM in a diffusion flame of paraffin fuels

Furuhata, T. *et al. Fuel*, 2012, 91, (1), 16–25.

Nanometre-sized particulate matter (PM) and polycyclic aromatic hydrocarbons (PAHs) have harmful effects on human health. Fundamental research works for investigation of formation behaviour of PAHs in combustion process were required for the reduction of nano-PM emission. In this paper, PAHs, soot and PM components in diffusion flames of paraffin fuels were investigated using laser diagnostics and direct sampling measurement. Methane (CH_4), propane (C_3H_8) and hexane (C_6H_{14}) were used as test fuels. A laser-induced fluorescence (LIF) method was used to obtain spatial distribution of PAHs that were precursor molecules of soot. Spatial distribution of soot was also measured by a laser-induced incandescence (LII) method. A transition region from PAHs to soot was defined from the results of LIF and LII. Further, PAH concentrations in test flames were analysed using a gas chromatography (GC). Relationship between fuel and a GC profile of PAH concentrations in these flames was discussed. PM components such as soot and soluble organic fraction (SOF) were also measured using a combustion type PM analyser (MEXA-1370PM). These results suggested that PAH molecules rapidly grew up to soot particles in the sooting region in a flame. It was confirmed that single-ring aromatic molecules such as benzene and toluene existed in the sooting region. Concentrations of PAHs such as fluorene and pyrene in the sooting region were far lower than single-ring aromatic molecules. Further, single-ring aromatic molecules such as benzene and toluene were emitted from the flame tip. As for the fuel effect, when carbon number of fuel molecule increased, PAH formation region was shifted to the upstream region in the flame. PM concentration in the flame increased with an increase of the carbon number of fuel.

12/01275 Characteristics of co-combustion of anthracite with bituminous coal in a 200-MWe circulating fluidized bed boiler

Lee, J. M. *et al. Energy*, 2011, 36, (9), 5703–5709.

The effect of co-combustion of Vietnamese anthracite with Australian bituminous coal on the performance of a commercial circulating fluidized bed boiler was observed in the Tonghae thermal power plant. The temperature in the cyclone exit of the boiler increased slightly, which caused a decrease in the desulfurization efficiency as the co-combustion ratio of the bituminous coal increased from 40 to 100%. The unburned carbon fraction also increased. Consequently, the fine particles of the bituminous coal had lower combustion reactivity than those of the anthracite. NO_x emissions decreased as the bituminous coal ratio increased, although the fraction of nitrogen in the bituminous coal was higher than that in the anthracite. However, the emission of dust was found to increase due to an increase in the amount of CaO and MgO in the fly ash, which could lower the efficiency of the electrostatic precipitator. From these results, it is concluded that the complete switch from the anthracite to Australian bituminous coal was possible, although the efficiency and the operation stability became lower than before. Additionally, as a future study, it is necessary to monitor the instability of the temperature increase and its effect on the prolonged clinker formation in the boiler.

12/01276 Deactivation performance and mechanism of alkali (earth) metals on V_2O_5–WO_3/TiO_2 catalyst for oxidation of gaseous elemental mercury in simulated coal-fired flue gas

Wan, Q. *et al. Catalysis Today*, 2011, 175, (1), 189–195.

Catalysis deactivation caused by alkali (earth) metals (Na, K, Mg and Ca) over V_2O_5–WO_3/TiO_2 catalyst for oxidation of Hg^0 by hydrogen chloride was investigated in the presence of O_2. Deactivation effects caused by alkali (earth) metals were well associated with alkalinity value and shown in sequence as: $K > Na \sim Ca > Mg$. Results also indicated that the deactivation increased proportionately with alkali (earth) metal doping amounts. Further investigations on BET surface area, XRD, Hg-TPD, XPS and H_2-TPR demonstrated that surface characteristics were not the dominant factor for the deactivation. However, surface coverage by alkali (earth) metals might cause decrease in the surface area and total pore volume. Hg-TPD results indicated that the doping of alkali (earth) metals would decrease surface Hg^0 adsorption amount associated with alkalinity value. More decrease of surface adsorption and redox ability (Oα) in doped catalysts than the fresh one could lead to less active performance according to the H_2-TPR and XPS of O 1s results. Consequently, the decrease of Hg^0 adsorption and surface redox ability (Oα), and the formation of inactive metavanadate species such as KVO_3 could be responsible for the deactivation performance caused by alkali (earth) metals over vanadium-based catalyst for oxidation of gaseous elemental mercury.

12/01277 Effect of catalyst formulation (Rh, Rh–Pt) on the performance of a natural gas hybrid catalytic burner

Cimino, S. *et al. Catalysis Today*, 2011, 171, (1), 72–78.

An extensive experimental campaign was carried out on a prototype hybrid radiant burner with ultra-low emissions based on the novel concept of fuel-rich catalytic + homogeneous flame combustion with interstage heat transfer. Special attention was paid to the impact of two alternative active formulations for the catalytic partial oxidation stage (0.5% Rh and 0.25–0.25% Rh–Pt on γ-Al_2O_3) on the general performance of the burner, and particularly on its NO_x emissions. The hybrid burner was operated with methane in the 4–30 kW power range, at varying the feed equivalence ratio ϕ from 2.0 to 3.6. Infrared thermography was used to simultaneously investigate the catalytic surfaces and the corresponding subsequent diffusion flames. Moreover this work attempts to correlate detailed experimental data on syn-gas compositions at the exit of the CPO reactor with emissions in the exhaust. Experimental evidence of the reduction of both thermal and prompt NO_x formation mechanism is presented.

12/01278 Estimation of the minimum Prandtl number for binary gas mixtures formed with light helium and certain heavier gases: application to thermoacoustic refrigerators

Campo, A. *et al. Applied Thermal Engineering*, 2011, 31, (16), 3142–3146.

This paper addresses a detailed procedure for the accurate estimation of low Prandtl numbers of selected binary gas mixtures. In this context, helium (He) is the light primary gas and the heavier secondary gases are nitrogen (N_2), oxygen (O_2), xenon (Xe), carbon dioxide (CO_2), methane (CH_4), tetrafluoromethane or carbon tetrafluoride (CF_4) and sulfur hexafluoride (SF_6). The three thermophysical properties forming the Prandtl number of binary gas mixtures Pr_{mix} are heat capacity at constant pressure $C_{p,mix}$ (thermodynamic property), viscosity η_{mix} (transport property) and thermal conductivity λ_{mix} (transport property), which in general depend on temperature T and molar gas composition w. The precise formulas for the calculation of the trio $C_{p,mix}$, η_{mix}, and λ_{mix} are gathered from various dependable sources. When the set of computed Pr_{mix} values for the seven binary gas mixtures $He + N_2$, $He + O_2$, $He + Xe$, $He + CO_2$, $He + CH_4$, $He + CF_4$, $He + SF_6$ at atmospheric conditions $T = 300\,K$, $p = 1\,atm$ is plotted against the molar gas composition w on the w-domain [0,1], the family of Pr_{mix} (w) curves exhibited distinctive concave shapes. In the curves format, all Pr_{mix} (w) curves initiate with $Pr \approx 0.7$ at $w = 0$ (associated with light primary He). Forthwith, each Pr_{mix} (w) curve descends to a unique minimum and thereafter ascend back to $Pr \approx 0.7$ at the terminal point $w = 1$ (connected to heavier secondary gases). Overall, it was found that among the seven binary gas mixtures tested, the $He + Xe$ gas mixture delivered the absolute minimum Prandtl number $Pr_{mix,min} = 0.12$ at the optimal molar gas composition $w_{opt} = 0.975$.

12/01279 Evolution of the nanostructure, fractal dimension and size of in-cylinder soot during diesel combustion process

Li, Z. *et al. Combustion and Flame*, 2011, 158, (8), 1624–1630.

The nanostructure, fractal dimension and size of in-cylinder soot during diesel combustion process have been investigated for a heavy-duty direct injection diesel engine, using a total cylinder sampling system followed by high-resolution transmission electron microscopy and Raman scattering spectrometry. Different structural organizations of in-cylinder soot are found depending upon the combustion phase. It is revealed that both the fringe tortuosity and separation distance decrease as combustion proceeds, while the mean fringe length increases distinctly from 1.00 to 2.13 nm, indicating the soot evolution toward a more graphitic structure during the combustion process. The fractal dimensions of aggregates are in a range of 1.20–1.74 at various crank angles under the applied engine operating conditions. As temperature and pressure increase, the fractal dimension decreases significantly to a minimum at the early diffusion combustion stage. The soot particles become more compact again as the fractal dimension increases during the subsequent combustion period. Primary particle sizes start small, go through a maximum in the early diffusion combustion phase and decline again as combustion proceeds.

12/01280 Experimental examination of flame chemistry in hydrogen sulfide-based flames

Selim, H. *et al. Applied Energy*, 2011, 88, (8), 2601–2611.

Spectroscopic examination of the emission spectra of excited species in hydrogen/air flames both without and with H_2S addition and in hydrogen sulfide/oxygen flame are conducted. The baseline case of hydrogen/air flame showed one distinct global peak of OH* at 309.13 nm. However, higher resolution spectrum analysis showed the presence of three major OH* peaks at 306.13, 309.09, and 312.9 nm. The addition of hydrogen sulfide to hydrogen/air flame resulted in the presence of a bluish cone located at inner regions of the flame. The spectrum of the blue cone showed group of peaks in the 350–470 nm spectral range. The addition of H_2S drastically reduced the peak value of OH* due to extensive consumption of the hydroxyl group during H_2S combustion. The group of peaks in the blue cone spectrum can be divided into three major bands. The first band is formed by SO* within 320–350 nm, the second band is attributed to SO^*_3 within 350–400 nm, and the third band is caused by H* within 400–470 nm. However, the distinction of SO^*_3 band and H* band around 400 nm is an issue that requires further examination. Absorption bands of SH were observed at 324.03 nm and 328.62 nm. The effect of sulfur dioxide on the spectrum was observed by neither emission bands nor absorption bands because of its reaction with elemental oxygen to produce excited sulfur trioxide. Gas chromatography analysis showed that combustion products did not contain any SO_2. The spectra of H_2S/O_2 flame have also been examined under lean conditions (at $\Phi = 0.5$). In contrast to H_2/air/H_2S flames, the spectra of H_2S/O_2 showed strong absorption bands of SO_2 within 280–310 nm. Strong continuum was observed between 280 and 460 nm with distinct group of peaks superimposed in the spectra. The continuum is attributed to the afterglow of singlet and triplet SO_2. The superimposed peaks are attributed to SO^*_3 and H*.

12/01281 Experimental study of biogas combustion in an HCCI engine for power generation with high indicated efficiency and ultra-low NO_x emissions

Bedoya, I. V. *et al. Energy Conversion and Management*, 2012, 53, (1), 154–162.

Combustion parameters and the main exhaust emissions from a biogas-fuelled HCCI engine are investigated in this study. The study was conducted on a four-cylinder, 1.9-litre Volkswagen TDI Diesel engine, which was modified to run in HCCI mode with biogas by means of inlet charge temperature control, boosted intake pressure, and a sonic flow device upstream of the inlet manifold to control biogas composition and the equivalence ratio. For simulating typical power generation conditions, the engine was coupled to an AC motor generator operating at 1800 rpm. In the start-up process, gasoline was used in HCCI mode for all cylinders. During the tests, biogas was used in cylinders 2 and 3, and gasoline was used in cylinders 1 and 4 to allow for more stable engine coolant and oil temperatures. The tests were performed through an experimental factorial design to evaluate the effect of inlet charge temperature, boost pressures, and the equivalence ratio of the biogas–air mixture on HCCI combustion parameters and emissions. For biogas at lower equivalence ratios, slight increases in inlet charge temperature and boost pressures enhanced combustion parameters and reduced CO and HC emissions. For biogas at higher equivalence ratios, the effects of inlet charge conditions on HCCI combustion and CO and HC emissions were attenuated; however, ringing intensities and NO_x emissions were increased with higher inlet charge temperature and higher boosted pressures. The maximum gross indicated mean effective pressure was 7.4 bar, the maximum gross indicated efficiency was close to 45%, and NO_x emissions were below the US-2010 limit of 0.27 g/kW h. These results show that a biogas-fuelled HCCI engine is a promising option in stationary power generation applications, meeting high efficiency and ultra-low NO_x emissions.

12/01282 Experimental study on self-excitations in nitrogen-diluted laminar lifted butane flames

Yoon, S. H. *et al. Fuel*, 2012, 91, (1), 51–60.

Laminar lifted butane flames diluted with nitrogen have been investigated experimentally to determine distinctive self-excitation regimes in the flame stability maps and also to elucidate the individual self-excitation characteristics. Self-excitations of lift-off height are classified into five regimes in laminar free-jet lift-off butane flames diluted with nitrogen: a stationary lifted regime (regime I), a heat-loss-induced self-excitation (regime II), a buoyancy-induced self-excitation due to flame flicker as well as a heat-loss-induced self-excitation (III), a combined form of an oscillation prior to blow-out and a heat-loss-induced oscillation (regime IV), and a combined form of an buoyancy-induced self-excitation and a heat-loss-induced oscillation as well as an additional buoyancy-driven self-excitation due to flame flicker (regime V). Extremely low-frequency (<0.1 Hz) self-excitation is caused by conductive heat loss from the premixed wings to the trailing diffusion flame and can be explained by a proposed mechanism. It is also found that the flame oscillation prior to flame blow-out is also caused by buoyancy and also significantly affected by the conductive heat loss from the premixed wings to the trailing diffusion flame, thereby showing that the frequency with nozzle exit velocity increases in the triple-flame propagation mode and then decreases in the flame-front propagation mode. Characterization of the individual self-excitation mode is presented and also discussed with Strouhal numbers and its relevant parameters through the analysis of power spectrum for temporal variation of lift-off height.

12/01283 Experimental study on the effect of different CO_2 concentrations on soot and gas products from ethylene thermal decomposition

Abián, M. *et al. Fuel*, 2012, 91, (1), 307–312.

This paper reports a laboratory study of the influence of environments with different CO_2 levels, representative of conditions in which exhaust gas recirculation is used in combustion systems, on soot and gas products formed in the thermal decomposition of ethylene–CO_2 mixtures. The investigation includes experiments, in a flow reactor, with 30,000 ppm of ethylene at different experimental conditions of temperature (975–1475 K) and CO_2 concentrations (25%, 50% and 78.5%), using nitrogen as bulk gas. The analysis is performed by comparison with the data obtained during the pyrolysis of ethylene in a N_2 atmosphere. The present results highlight the importance of the CO_2 level in the system, since the presence of 25% CO_2 tends to promote the formation of soot, whereas an increased CO_2 addition of 78.5% leads to a diminution in the production of soot, compared to the pyrolysis of pure ethylene in N_2. The different evolution in soot formation tendencies can be attributed to competing reactions that gain importance depending on the different CO_2 levels, boosting or suppressing soot formation as function of the composition of both the O/H radical pool and the reacting species. The outlet concentrations of H_2, CO and C_2H_2, as well as the formation of H_2O, are directly related to the different soot-forming tendency found as function of different CO_2 environments.

12/01284 Importance of activity data for improving the residential wood combustion emission inventory at regional level

Pastorello, C. *et al. Atmospheric Environment*, 2011, 45, (17), 2869–2876.

The contribution of residential wood combustion (RWC) to emission inventory at local level was estimated using a bottom–up approach for the Lombardy region of north Italy. A survey, based on a computer-assisted telephone interviewing method, has been undertaken through 18,000 interviews. The interviews had the objective to characterize the RWC use in this region, in term of both total and municipal wood consumption. Details on the type of appliances used in RWC were also gathered. The results of the survey were then statistically analysed in order to allow an estimate of RWC with high spatial resolution (i.e. at municipal level) in relation to the size and altitude of the territory. The work provides new evidence of the importance of wood combustion as a key source for PM and NMVOC emissions at local level, and thus highlights the importance of technological improvements and new policies aimed at emission reduction in this sector. Considering the great differences in average PM emission factors between low efficiency appliances (fireplaces, old stoves) and high efficiency ones (new stoves, pellet burners), this work emphasizes the importance of obtaining more detailed information on the types of wood appliances used for arriving at a reliable PM emission inventory for RWC.

12/01285 On flame stability, temperature distribution and burnout of air-staged porous media combustor firing LPG with different porosity and excess air

Charoensuk, J. and Lapirattanakun, A. *Applied Thermal Engineering*, 2011, 31, (16), 3125–3141.

A porous combustor burning partially premixed LPG with staged air is investigated prior to be used as a prime heat source in a hydrogen production unit of solid oxide fuel cell system. It has 325 mm in height with 100 mm of inside diameter. The small amount of air is mixed with liquid petroleum gas at the bottom of the combustor and the rest is staged at 0 and 100 mm next to the distributor plate. Thermal throughput is kept at 3 kW with the excess air ranging from 110% to 180%. Temperature distributions are investigated for three values of porosity and linked with Peclet number, convection and turbulent mixing of hot product and unburned reactant. Experimental data suggested that it is reasonable to use Peclet number calculated using the flame speed of propane to determine the combustion stability. Low and well-distributed temperature profile is achieved. The apparatus meets the design criteria with staged air but caution must be made to avoid over-staging. An important operation criterion is found in the mixture preheating zone; the temperature level within the distance of 100 mm. from the distributor plate must be higher than 800 °C for a sufficient level temperature throughout the burner domain.

12/01286 Parametric optimization study of a multi-burner flameless combustion furnace

Danon, B. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 3000–3008.

A parametric study on a 300 kW_{th} furnace equipped with three pairs of regenerative flameless combustion burners has been performed. Each burner pair has a rated thermal power of 100 kW_{th} firing Dutch natural gas. The objective of the study was to optimize the furnace performance, i.e., to maximize the cooling tube efficiency and minimize the CO and NO emissions. In the study the following parameters were varied: the positions of the burners in the furnace (burner configuration), the firing mode (parallel and staggered), the excess air ratio (λ) and the cycle time (t_{cycle}). Also, the influence on the furnace performance of the jet momentum of the combustion air and the temperature uniformity in the furnace were studied. It was concluded that staggered firing mode is disadvantageous, since it results in significantly higher NO emissions than parallel firing mode. Also, out of the five investigated burner configurations one has been exempted, since its cooling tube efficiency was significantly lower compared to the other configurations. Furthermore, a horizontal setup of the firing burners improves the cooling tube efficiency at a fixed temperature uniformity. Also, for the burner configurations with the firing burners positioned closer to the regenerating burners and further from the stack, the temperatures in the regenerators are higher, leading to higher combustion air preheat temperatures. The temperature in the regenerators was also influenced by the cycle time; higher cycle times leading to higher (peak) temperatures in the regenerators. Finally, this temperature in the regenerators was shown to be more decisive for the final amount of CO emitted than the excess air ratio or the jet momentum. In all experiments, due to differences in path length of the mean flow, higher CO emissions were measured in the flue gas from the regenerators compared to in the flue gas from the stack. These two trends in the CO emissions were not observed for the NO emissions.

12/01287 Performance modeling of radiant heat recovery exchangers for rotary kilns

Caputo, A. C. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2578–2589.

Heat loss from rotating kilns may represent a significant percentage of the total energy input especially in highly energy intensive industrial sectors such as cement production. As an alternative to traditional energy recovery methods, the possibility of recovering radiant heat lost through the kiln surface has been proposed in the literature. This may be accomplished by surrounding the kiln with a secondary external shell acting as a heat exchanger for a transfer fluid. In this work a mathematical model for sizing and performance estimation of a heat exchanger recovering waste heat from the external surface of rotating kilns is developed. The equipment has been configured as an array of pressurized water carrying tubes arranged in a longitudinal pattern on the surface of a cylindrical outer shell coaxial with the rotary kiln. An example of model application is utilized to discuss the involved heat transfer process and its impact on equipment design. An economic model has also been developed to determine the optimal size of the equipment.

12/01288 PMMA-templating preparation and catalytic properties of high-surface-area three-dimensional macroporous La_2CuO_4 for methane combustion

Yuan, J. *et al. Catalysis Today*, 2011, 175, (1), 209–215.

Three-dimensional (3D) macroporous orthorhombically crystallized perovskite-like oxides La_2CuO_4 were prepared using the polymethyl methacrylate (PMMA) microsphere-templating strategy with nitrates of lanthanum and copper as metal source and a mixed solution of methanol and ethylene glycol as solvent in the absence or presence of citric acid and after calcination at various atmospheres. The as-prepared materials were characterized by means of X-ray diffraction, N_2 adsorption-desorption, scanning electron microscopy, X-ray photoelectron spectroscopy, and hydrogen temperature-programmed reduction. Catalytic activities of the materials were evaluated for the combustion of methane. The catalyst (La_2CuO_4-1) prepared with PMMA and citric acid possessed a 3D ordered macroporous (3DOM) structure and a surface area up to 46 m^2/g, whereas the one (La_2CuO_4-2) prepared with PMMA but without citric acid exhibited a 3D wormhole-like macroporous structure and a surface area of 39 m^2/g. There was the presence of a trace amount of $La_2O_2CO_3$ phase in the La_2CuO_4-1 and La_2CuO_4-2 catalysts. The calcination procedure (first in N_2 flow at 700 °C and then in air flow at 300 and 800 °C, respectively) was crucial in forming the 3D porous structure of La_2CuO_4. The as-obtained catalysts had overstoichiometric oxygen. The La_2CuO_4-1 catalyst showed better low-temperature reducibility than the La_2CuO_4-2 and La_2CuO_4-citrate (derived from the conventional citric acid-complexing route) catalysts. The 3D porous La_2CuO_4 materials performed well in catalysing the oxidation of methane, with the La_2CuO_4-1 catalyst showing the best performance (the temperature for 90% CH_4 conversion = 672 °C (reaction rate = ca. 40 mmol/(g h)) at CH_4/O_2 molar ratio = 1/10 and space velocity = 50,000 mL/(g h). It is concluded that the excellent catalytic performance of La_2CuO_2-1 was mainly related to the higher surface area, better low-temperature reducibility, and 3DOM architecture.

12/01289 Quantification of the active site density and turnover frequency for soot combustion with O_2 on Cr doped CeO_2

Li, X. *et al. Catalysis Today*, 2011, 175, (1), 112–116.

The soot combustion on Cr-doped CeO_2 mixed oxides was studied. The catalysts were characterized by X-ray powder diffraction, N_2 adsorption/desorption, X-ray photoelectron spectroscopy and temperature-programmed reduction with H_2. The active sites were quantified using isothermal anaerobic titrations with soot as the probe molecule. The turnover frequency (TOF) was calculated and used to evaluate the activity. The samples with a Cr/(Cr + Ce) ratio within 1–3 at.% show an improved activity on the basis of reaction rates and TOF values. The active sites were determined to be composed of Ce–O–Ce species, which is a little more active compared with CeO_2 due to the promotion by the doping of Cr. Although the similar reaction rates were observed, the doping of 5 at.% Cr results in a detectable decrease of the TOF compared with CeO_2. This is because the active sites are composed of Cr–O–Ce species. The strong interaction of the supported CrO_x species with CeO_2 results in an increase in the activity of Cr_2O_3. The promotional effect of Fe to CeO_2 on soot combustion is more significant than that of Cr. The TOF is strongly recommended to be the basis of the activity comparison.

12/01290 Swirling distributed combustion for clean energy conversion in gas turbine applications

Khalil, A. E. E. and Gupta, A. K. *Applied Energy*, 2011, 88, (11), 3685–3693.

Distributed combustion provides significant performance improvement of gas turbine combustors. Key features of distributed combustion includes uniform thermal field in the entire combustion chamber, thus avoiding hot-spot regions that promote NO_x emissions (from thermal NO_x) and significantly improved pattern factor. Rapid mixing between the injected fuel and hot oxidizer has been carefully explored for spontaneous ignition of the mixture to achieve distributed combustion reactions. Distributed reactions can be achieved in premixed, partially premixed or non-premixed modes of combustor operation with sufficient entrainment of hot and active species present in the flame and their rapid turbulent mixing with the reactants. Distributed combustion with swirl is investigated here to explore the beneficial aspects of such flows on clean combustion in simulated gas turbine combustion conditions. The goal is to develop high intensity combustor with ultra-low emissions of NO and CO, and much improved pattern factor. Experimental results are reported from a cylindrical geometry combustor with different modes of fuel injection and gas exit stream location in the combustor. In all the configurations, air was injected tangentially to impart swirl to the flow inside the combustor. Ultra-low NO_x emissions were found for both the premixed and non-premixed combustion modes for the geometries investigated here. Swirling flow configuration, wherein the product gas exits axially resulted in characteristics closest to premixed combustion mode. Change in fuel injection location resulted in changing the combustion characteristics from traditional diffusion mode to distributed combustion regime. Results showed very low levels of NO (~3 ppm) and CO (~70 ppm) emissions even at rather high equivalence ratio of 0.7 at a high heat release intensity of 36 MW/m^3-atm with non-premixed mode of combustion. Results are also reported on lean stability limit and OH* chemiluminescence under both premixed and non-premixed conditions for determining the extent of distribution combustion conditions.

12/01291 Thermogravimetric analysis of microalgae combustion under different oxygen supply concentrations

Chen, C. *et al. Applied Energy*, 2011, 88, (9), 3189–3196.

Recently, studies of microalgae in China have increased a lot because of their obvious advantages over other biological fuels. In this paper, the combustion behaviour of *Chlorella vulgaris* (a genus of unicellular green microalgae) was investigated in a thermogravimetric analyser (TGA) from room temperature to 800 °C in O_2/N_2 atmospheres. The effects of different oxygen concentrations (20, 50, 60, 80 vol.%) and different heating rates (10, 20 and 40 $°C\,min^{-1}$) on the combustion processes of *C. vulgaris* had been studied. The results indicated that the combustion processes of *C. vulgaris* could be divided into three stages. The oxygen concentrations and heating rates had important effects on the main combustion processes of *C. vulgaris*. The iso-conversional method involving Flynn–Wall–Ozawa (FWO) and the Kissinger–Akahira–Sunose (KAS) methods were used for the kinetic analysis of the main combustion process. The results indicated that, when the oxygen concentration varied from 20 to 80 vol.%, the value of activation energy increased respectively from 134.03 to 241.04 $kJ\,mol^{-1}$ 1 by using FWO method and from 134.53 to 242.33 $kJ\,mol^{-1}$ by KAS method. Moreover, the optimal oxygen concentration for *C. vulgaris* combustion was 25–35 vol.%.

Fire safety

12/01292 Analysis of hydrogen risk mitigation with passive autocatalytic recombiner system in CPR1000 NPP during a hypothetical station blackout

Huang, X. G. *et al. Annals of Nuclear Energy*, 2011, 38, (12), 2762–2769.

Hydrogen safety has attracted extensive concern in severe accident analysis especially after the Fukushima accident. In this study, a similar station blackout as happened in Fukushima accident is simulated for CPR1000 nuclear power plant (NPP) model, with the computational fluid dynamic code GASFLOW. The hydrogen risk is analysed with the assessment of efficiency of passive autocatalytic recombiner (PAR) system. The numerical results show that the CPR1000 containment may be damaged by global flame acceleration (FA) and local detonation caused by hydrogen combustion if no hydrogen mitigation system (HMS) is applied. A new condensation model is developed and validated in this study for the consideration of natural circulation flow pattern and presence of non-condensable gases. The new condensation model is more conservative in hydrogen risk evaluation than the current model in some compartments, giving earlier starting time of deflagration to detonation transition (DDT). The results also indicate that the PAR system installed in CPR1000 could prevent the occurrence of the FA and DDT. Therefore, HMS such as PAR system is suggested to be applied in NPPs to avoid the radioactive leak caused by containment failure.

12/01293 Effect of low temperature on the flammability limits of methane/nitrogen mixtures

Li, Z. *et al. Energy*, 2011, 36, (9), 5521–5524.

An experimental setup was established to measure the flammability limits of flammable gases at low temperatures. The flammability limits of methane/nitrogen mixtures in air were measured at atmospheric pressure and wide temperature range from 150 to 300 K. The estimated uncertainty of the experimental values was 0.2 vol%. The results reveal that as initial temperature decreases, the upper flammability limits (UFL) decrease while the lower flammability limits (LFL) increase. Therefore, the critical flammability ratio (CFR) decreases as the initial temperature decreases. In addition, the variation in the UFL is more sensitive than that in the LFL as the molar ratio of nitrogen to methane increases. In addition, an extended Le Chatelier's formula with higher-order and temperature terms was proposed to correlate and predict the flammability limits at each temperature. The calculated values conformed to the experimental results for both the LFL and the UFL.

12/01294 Experimental study and numerical simulation for a storehouse fire accident

Yang, P. *et al. Building and Environment*, 2011, 46, (7), 1445–1459.

Full-scale experiment and numerical simulations are carried out on a shelf fire in a storehouse to study the ignition manner, the fire spread and the combustion characteristics. A computational fluid dynamics (CFD) model of fire-driven fluid flow, fire dynamics simulator (FDS), is used to solve numerically a form of the Navier–Stokes equations for fire. Ignition manner experiments with both cigarette ends and lighter are conducted first. Then a full-scale experiment on a shelf fire is performed. The temperatures are measured and the fire growth and spread process is analysed. A numerical model is used to simulate the experiment; the temperatures, fire growth and heat release rate are studied. In numerical simulations, the grid size resolution is analysed. The experimental results of temperatures and the fire growth and spread process are compared with the results of numerical simulations. It shows that the numerical results are in good agreement with the experimental results. The chimney effect is also observed in both the experiment and the simulation. These useful data can be helpful in the numerical reconstruction of the whole storehouse fire accident.

12/01295 Flame synthesis of graphene films in open environments

Memon, N. K. *et al. Carbon*, 2011, 49, (15), 5064–5070.

Few-layer graphene is grown on copper and nickel substrates at high rates using a novel flame synthesis method in open-atmosphere environments. Transmittance and resistance properties of the transferred films are similar to those grown by other methods, but the concentration of oxygen, as assessed by X-ray photoelectron spectroscopy, is actually less than that for graphene grown by chemical vapour deposition under near vacuum conditions. The method involves utilizing a multi-element inverse-diffusion-flame burner, where post-flame species and temperatures are radially uniform upon deposition at a substrate. Advantages of the specific flame synthesis method are scalability for large-area surface coverage, increased growth rates, high purity and yield, continuous processing, and reduced costs due to efficient use of fuel as both heat source and reagent. Additionally, by adjusting local growth conditions, other carbon nanostructures (i.e. nanotubes) are readily synthesized.

12/01296 Improvement of passive fire protection in a gypsum panel by adding inorganic fillers: experiment and theory

Ciudad, A. *et al. Applied Thermal Engineering*, 2011, 31, (17–18), 3971–3978.

Passive fire protection is currently a field of active interest in building technology. One of the different approaches to obtain a material that provides this protection is to add substances to the initial formulation that are capable to absorb heat when the temperature of the material is increased. This is achieved by means of endothermic reactions that these substances undergo at specified temperatures. In the case of a fire scenario huge amounts of heat are released and such heat absorbing reactions delay the achievement of temperatures that can be critical for structural stability. In this work the behaviour of gypsum is specifically analysed, which is commonly used in buildings. In order to enrich its endothermic profile, magnesium hydroxide, calcium hydroxide and calcium carbonate were added to the sample. These three alkaline earth components have their heat absorbing peaks located along the temperature domain in a way that the temperature rising is reasonably damped. The main result is that when these three fillers are added to gypsum, the protection offered by the new combination of materials is significantly improved with respect to the behaviour of gypsum alone. Under external heating, the component is able to keep itself under critical temperatures for a longer period. For the theoretical description, non-isothermal thermogravimetry (TG) was used to analyse and characterize the kinetic response of each component of the mixture. A conversion function is proposed which is based on the correlation between consecutive reactions in neighbouring molecules. The heating rate is included in the model as an analytical variable. Later, high-temperature tests are performed in a tubular furnace and their corresponding numerical simulations where heat transfer is explicitly carried and mass transfer effects are discussed.

12/01297 Performance evaluation of water mist with bromofluoropropene in suppressing gasoline pool fires

Ni, X. and Chow, W. K. *Applied Thermal Engineering*, 2011, 31, (17–18), 3864–3870.

Both clean fire suppressing agents, water mist and degradable bromofluoropropene have their limitation in application. Water mist is environment-friendly, but has difficulties in extinguishing small liquid fuel fires in compartments with good ventilation. Clean agent 2-bromo-3,3,3-trifluoropropene (BTP) is efficient in extinguishing liquid fuel fires, but generates toxic hydrogen fluoride. Combining water mist with BTP would overcome their respective drawbacks in fire suppression. Performance of a portable BTP–water mixture in suppressing gasoline pool fires evaluated by laboratory-scale experiments will be reported in this presentation. Results demonstrated that combining water mist with BTP would extinguish fires through physical and chemical mechanisms, taking the advantage of high efficiency and low concentration of acid gas. Furthermore, residue clean problems accompanying the conventional additives of metallic salts or surfactants to water mist would not be found.

12/01298 Reliability data update method for emergency diesel generator of Daya Bay nuclear power plant

Zubair, M. and Zhang, Z. *Annals of Nuclear Energy*, 2011, 38, (11), 2575–2580.

In the field of living probabilistic safety assessment (LPSA) the reliability data updating is an important factor. In risk analysis equipment failure data is needed to estimate the frequencies of events contributing to risk posed by a facility. Five years' data of emergency diesel generator (EDG) of Daya Bay nuclear power plant (NPP) has been studied in this paper. The data updating process has been done by using two methods, i.e. the classical method and Bayesian method. The aim of using these methods is to calculate the operational failure rate (λ) and demand failure probability (p). The results show that the operational failure rate is 1.7×10^{-3} per hour and the demand failure probability is 2.4×10^{-2} demand per day for Daya Bay NPP. By comparing the results obtain from classical and Bayesian methods with Électricité de France (EDF) it is concluded that the design and construction of Daya Bay NPP is very different than EDF therefore the reliability parameters used in Daya Bay NPP is based on the classical method.

12/01299 Upward flame spread over corrugated cardboard

Gollner, M. J. *et al. Combustion and Flame*, 2011, 158, (7), 1404–1412.

As part of a study of the combustion of boxes of commodities, rates of upward flame spread during early-stage burning were observed during experiments on wide samples of corrugated cardboard. The rate of spread of the flame front, defined by the burning pyrolysis region, was determined by visually averaging the pyrolysis front position across the fuel surface. The resulting best fit produced a power-law progression of the pyrolysis front, $x_p = At^n$, where x_p is the average height of the pyrolysis front at time t, $n = 3/2$, and A is a constant. This result corresponds to a slower acceleration than was obtained in previous measurements and theories (e.g. $n = 2$), an observation which suggests that development of an alternative description of the upward flame spread rate over wide, inhomogeneous materials may be worth studying for applications such as warehouse fires. Based upon the experimental results and overall conservation principles it is hypothesized that the non-homogeneity of the cardboard helped to reduce the acceleration of the upward spread rates by physically disrupting flow in the boundary layer close to the vertical surface and thereby modifying heating rates of the solid fuel above the pyrolysis region. As a result of this phenomena, a distinct difference was observed between scalings of peak flame heights, or maximum 'flame tip' measurements and the average location of the flame. The results yield alternative scalings that may be better applicable to some situations encountered in practice in warehouse fires.

09 PROCESS HEATING, POWER AND INCINERATION

Energy applications in industry

12/01300 A new approach for synchronous generator terminal voltage control – comparison with a standard industrial controller

Barakat, A. *et al. Electric Power Systems Research*, 2011, 81, (7), 1592–1601.

This paper deals with the design and evaluation of a single input single output H_∞ voltage controller. The proposed approach is based on optimizing the system modelling in order to obtain a robust and high performance controller. The adopted methodology is realized in five steps: (1) modelling of the exciter machine, the main synchronous generator, and the rotating diode bridge; (2) linearization of the excitation system; (3) using of a fictitious three-phase capacitor to represent the variable synchronous generator load as exogenous input of the system; (4) linearization of the feedback control by using a SISO (single input/single output) controller; (5) application of H_∞ control method associated with weighting functions. The performance of the controller has been evaluated by experimental tests under different operating points of the synchronous generator. In addition, the comparison with a standard industrial controller highlights the efficiency of the proposed design approach.

12/01301 A novel approach to develop the control of Telbot using ANFIS for nuclear hotcells

Lali, P. and Setayeshi, S. *Annals of Nuclear Energy*, 2011, 38, (10), 2156–2162.

This paper develops an improved controller for Telbot. Telbot is a new six DOF tele-robot, with special kinematic design, famous for working in nuclear hotcells. The recent controllers are based on simple and improved PID controllers, with visible tracking error. In this project, an ANFIS controller was designed and trained for controlling this tele-robot. The proposed controller generates an appropriate torque for reaching desired state, without any error. The controller was initialized with if-then rules. The training includes online and offline processes. The offline processes have light loads, and prepaid more than 90% of system desired, but the online processes do the last critical 10%, and remove all the errors. The controller is describing the high degree of non-linear dynamics behaviour of the Telbot. The final simulation shows the error-less tracking.

12/01302 A revised drag force model and the application for the gas–solid flow in the high-density circulating fluidized bed

Wang, X. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2254–2261.

The behaviour of the gas–solid two-phase flow plays a vital role in the heat and mass transfer in the high-density circulating fluidized bed. In this paper, based on the energy-minimization multi-scale (EMMS) model, a drag force coefficient model, which can be applied to different kinds of particle, is developed for investigating the hydrodynamic characteristics of the high-density circulating fluidized bed (HDCFB). Coupled with the two-fluid model and the kinetic theory of granular, a 3D full-loop numerical simulation is implemented to test the validity of the revised drag force coefficient model, and excellent numerical performances and encouraging results are obtained. Under the operated conditions, the simulation results are in excellent agreement with the experimental data, which reveals that the revised drag force coefficient model is competent for the HDCFB's numerical simulation.

12/01303 Analysis of electrical motors load factors and energy savings in an Indian cement industry

Thirugnanasambandam, M. *et al. Energy*, 2011, 36, (7), 4307–4314.

Electric motors consume in between 30% and 80% of the total industrial energy use for few selected countries around the world. It was identified that many motors are operated under loaded conditions. In some cases, motors are operated even at 3–16% of their full loads. These low loads can be optimized with the application of variable speed drives (VSD) to match the load requirements. Based on the estimation, it has been found that annually about 1,865,925 MWh of energy can be saved for 60% speed reduction when VSDs are used. It was also found that about 2,122,675 tons CO_2emission could be avoided annually by using VSDs for low tension (LT) motors for 60% speed reduction. It was also estimated that annually about 4,600,386 MWh of energy can be saved for high tension (HT) motors for 60% speed reduction using VSDs. The average payback period (PBP) for implementing VSDs for LT and HT motors found to be very low (i.e. about 2 days). In this particular study it is observed that installing both LT and HT capacitors to improve power factor found to be not economically viable owing to low level of energy savings.

12/01304 Analysis of flow structure inside a spool type pressure regulating valve

Chattopadhyay, H. *et al. Energy Conversion and Management*, 2012, 53, (1), 196–204.

The flow process inside a pressure regulating valve has been investigated using a computational fluid dynamic approach. The Navier–Stokes equation along with appropriate turbulent closure has been solved for this purpose in the compressible flow regime using FLUENT package. Investigations of the flow through valve at different valve opening and different pressure drop are presented. The standard k–ε model of turbulence was found to predict higher levels of turbulent kinetic energy and hence the realizable variant of k–ε model was adopted for turbulence closure. Within the operating zone, it is found that two-dimensional axi-symmetric formulation can capture the gross flow parameters quite well. However, for complete realization of the turbulent field, three dimensional analyses assume importance. The realizable k–ε model was found to be an attractive option for turbulence modelling.

12/01305 Biological pretreatment applied to industrial organic fraction of municipal solid wastes (OFMSW): effect on anaerobic digestion

Fdez.-Güelfo, L. A. *et al. Chemical Engineering Journal*, 2011, 172, (1), 321–325.

The application of the anaerobic digestion for the treatment of the industrial organic fraction of municipal solid waste (OFMSW) has currently been of special interest. The main barrier in the treatment of this type or organic waste is its biotransformation, due to the complexity of organic material. Therefore, the first step must be its physical, chemical and biological pretreatment for breaking complex molecules into simple monomers, to increase solubilization of organic material and improve the efficiency of the anaerobic treatment in the second step. This article describes the application of biological pretreatment based on mature compost addition, in order to enhance organic matter solubilization and, hence, the biogas and methane production and the organic matter removal during the anaerobic digestion of the industrial OFMSW. Laboratory-scale experiments were carried out in semicontinuous completely mixed reactor, 5-L capacity. Optimal conditions for organic matter solubilization in the first step of pretreatment were: mature compost as biological agent, 2.5% (v/v) of inoculation percentage and 24 h as incubation period. The anaerobic digestion efficiency of the industrial OFMSW, with and without pretreatment, was evaluated for a solid retention time of 15 days. Under those conditions the organic matter removal percentage, in terms of eliminated dissolved organic carbon and volatile solids, was increased up to 61.2% and 35.3% respectively over the control without pretreatment. As consequence, the biogas and methane production are improved up to 60.0% and 73.3% respectively. The highest cumulative biogas and methane production under anaerobic digestion were obtained with pretreated waste: 178.6 L and 82.6 L against 61.6 L and 34.2 L of the control without pretreatment. The results have shown that biological pretreatment with mature compost, followed by dry-thermophilic anaerobic digestion, provides the best results for stabilizing the industrial OFMSW.

12/01306 Catalytic cracking of n-heptane under activation of lattice oxygen in a circulating fluidized bed unit

Hu, X. *et al. Chemical Engineering Journal*, 2011, 172, (1), 410–417.

A circulating fluidized bed unit was used to evaluate influences of lattice oxygen introduction over catalytic cracking of n-heptane over HZSM-5 catalyst in a continuous reaction fashion. The results demonstrated that V_2O_5/Al_2O_3, which functioned as lattice oxygen supplier, promoted conversion of n-heptane in a much larger extent, compared with fixed-bed reactor. It also improved yields of propylene and butylenes, and intensified formation of aromatics and coke. Besides lattice oxygen species, some adsorbed oxygen species also participated into the reaction. CO and H_2O were formed as main oxygenated products. Steam introduction improved selectivity of propylene and butylenes, promoted desorption of strong adsorbed species in V_2O_5/Al_2O_3, and thus formation of coke was depressed; however, the damage to HZSM-5 framework was aggravated simultaneously.

12/01307 Characterization of industrial lignins for their utilization in future value added applications

Sahoo, S. *et al. Biomass and Bioenergy*, 2011, 35, (10), 4230–4237.

Lignin is a co-product of paper and lignocellulosic bioethanol industries. Structure and functionality of lignins differ from one another based upon the source material and isolation techniques adopted in various industries. Value added applications from lignins need a proper investigation of their inherent properties. Various types of industrial lignins were characterized through elemental analysis, Fourier transform infrared spectroscopy (FTIR), and thermogravimetric analysis (TGA) in order to understand the potential of these materials for future value added applications, with a major focus on composite materials. All the grades of Protobind lignins exhibited lower sulfur content and higher carbon content. The highest value of sulfur content was observed for Arbo S01 lignin (lignosulfonate). Among all the industrial lignins, Protobind 2400 exhibited higher thermal degradation onset, i.e. 174.5 °C followed by Arbo S01 (sodium lignosulfonate, 164.4 °C). Derivative thermogravimetric (DTG) curves of the lignins demonstrated the differences in their thermal behaviour. The DTG curve of Polybind 300 was quite different from the other lignins.

12/01308 Characterization of PAHs within PM_{10} fraction for ashes from coke production, iron smelt, heating station and power plant stacks in Liaoning Province, China

Kong, S. *et al. Atmospheric Environment*, 2011, 45, (23), 3777–3785.

Polycyclic aromatic hydrocarbons (PAHs) within PM_{10} fraction of ashes from two coke production plants, one iron smelt plant, one heating station and one power plant were analysed with GC–MS technique in 2009. The sum of 17 selected PAHs varied from 290.20 to 7055.72 μg/g and the amounts of carcinogenic PAHs were between 140.33 and 3345.46 μg/g. The most toxic ash was from the coke production plants and then from the iron smelt plant, coal-fired power plant and heating station according to BaP-based toxic equivalent factor (BaPeq) and BaP-based equivalent carcinogenic power (BaPE). PAHs profile of the iron smelt ash was significantly different from others with coefficient of divergence value higher than 0.40. Indicatory PAHs for coke production plants, heating station and coal-fired power plant were mainly three-ring species such as Acy, Fl and Ace. While for iron smelt plant, they were Chr and BbF. Diagnostic ratios including Ant/(Ant + Phe), Flu/(Flu + Pyr), BaA/Chr, BbF/BkF, Ind/BghiP, IND/(IND + BghiP), BaP/BghiP, BaP/COR, Pyr/BaP, BaA/(BaA + Chr), BaA/BaP and BaP/(BaP + Chr) were calculated which were mostly different from other stacks for the iron smelt plant.

12/01309 Combustion of polymer pellets in a bubbling fluidised bed

Burgess, F. *et al. Combustion and Flame*, 2011, 158, (8), 1638–1645.

Single pellets ($\approx$3 mm diameter) of high density polyethylene (HDPE) have been burned in an electrically heated bed of silica sand, fluidized by air or mixtures of N_2 and O_2 at atmospheric pressure. During the combustion of single pellets, measurements were made of the concentrations of CO and CO_2 in the off-gas, enabling burnout-times to be derived. This was done for different temperatures (400–900 °C) in a bubbling fluidized bed and a range of masses for the HDPE pellets. In addition, the size of the sand, the fluidizing velocity and the concentration of O_2 in the fluidizing gas were all varied. In a bed above 400 °C, a polymer pellet melted on entering the hot sand, which was wetted to form a small aggregate (or 'blob' $\sim$5 mm in diameter) of sand particles held together by molten polymer. Next, the blob sank and volatilization and thermal decomposition of the polymer produced hydrocarbon vapours, which burned mainly above the sand. It was deduced that there are actually three ranges of temperature, each with a different mechanism of combustion. With the bed in the high temperature regime at 640–900 °C, burnout was controlled by mass transfer of hydrocarbon vapour (deduced to have a mean composition of approximately $(C_2H_4)_5$) away from such a blob of sand and molten polymer. When the bed was between 485 and 640 °C (the medium temperature regime), radiative heat transfer to a blob of polymer controlled burnout. At 400–485 °C (the low temperature region) the burnout-time was controlled by the volatilization (gasification) of a polymer pellet to produce a combustible hydrocarbon vapour. The activation energy for this gasification was ~58 kJ/mol. This is the same as that characterizing the ignition delay, which was also measured. The measured rates of burning indicate an enthalpy of gasification of ≈450 J/g. The total yield of CO and CO_2 was found to depend on the bed's temperature and was low enough to indicate that soot, together with unburned hydrocarbons, can be important products from such a bed.

12/01310 Comparative assessment of CO_2 capture technologies for carbon-intensive industrial processes

Kuramochi, T. *et al. Progress in Energy and Combustion Science*, 2012, 38, (1), 87–112.

This article presents a consistent techno-economic assessment and comparison of CO_2 capture technologies for key industrial sectors (iron and steel, cement, petroleum refineries and petrochemicals). The assessment is based on an extensive literature review, covering studies from both industries and academia. Key parameters, e.g. capacity factor (91–97%), energy prices (natural gas: 8 $€_{2007}$/GJ, coal: 2.5 $€_{2007}$/GJ, grid electricity: 55 €/MWh), interest rate (10%), economic plant lifetime (20 years), CO_2 compression pressure (110 bar), and grid electricity CO_2 intensity (400 g/kWh), were standardized to enable a fair comparison of technologies. The analysis focuses on the changes in energy, CO_2 emissions and material flows, due to the deployment of CO_2 capture technologies. CO_2 capture technologies are categorized into short to mid-term (ST/MT) and long-term (LT) technologies. The findings of this study identified a large number of technologies under development, but it is too soon to identify which technologies would become dominant in the future. Moreover, a good integration of industrial plants and power plants is essential for cost-effective CO_2 capture because CO_2 capture may increase the industrial onsite electricity production significantly. For the iron and steel sector, 40–65 €/tCO_2 avoided may be achieved in the ST/MT, depending on the iron-making process and the CO_2 capture technique. Advanced LT CO_2 capture technologies for the blast furnace based process may not offer significant advantages over conventional ones (30–55 €/tCO_2 avoided). Rather than the performance of CO_2 capture technique itself, low-cost CO_2 emissions reduction comes from good integration of CO_2 capture to the iron-making process. Advanced smelting reduction with integrated CO_2 capture may enable lower steel production cost and lower CO_2 emissions than the blast furnace based process, i.e. negative CO_2 mitigation cost. For the cement sector, post-combustion capture appears to be the only commercial technology in the ST/MT and the costs are above 65 €/tCO_2 avoided. In the LT, a number of technologies may enable 25–55 €/tCO_2 avoided. The findings also indicate that, in some cases, partial CO_2 capture may have comparative advantages. For the refining and petrochemical sectors, oxyfuel capture was found to be more economical than others at 50–60 €/tCO_2 avoided in ST/MT and about 30 €/tCO_2 avoided in the LT. However, oxyfuel retrofit of furnaces and heaters may be more complicated than that of boilers. Crude estimates of technical potentials for global CO_2 emissions reduction for 2030 were made for the industrial processes investigated with the ST/MT technologies. They amount up to about 4 Gt/year: 1 Gt/year for the iron and steel sector, about 2 Gt/year for the cement sector, and 1 Gt/year for petroleum refineries. The actual deployment level would be much lower due to various constraints, about 0.8 Gt/year, in a stringent emissions reduction scenario.

12/01311 Comparison of the energy efficiency to produce agroethanol between various industries and processes: the transport stage

Chavanne, X. and Frangi, J.-P. *Biomass and Bioenergy*, 2011, 35, (9), 4075–4091.

The different modes of transport used in the agroethanol industry and their energy efficiencies have been studied. Their specific consumption of fuels t_{trans} in MJ $(t_{\mathrm{load}}\,\mathrm{km})^{-1}$ is assessed from raw data and from friction force laws. t_{trans} depends on the mode characteristics, fuel/engine performance, velocity, geometry, total mass, actual load, etc. Lack of precision on them increases the uncertainty on t_{trans} (variation by a factor up to eight for pipeline depending on the flow velocity). From t_{trans} is deduced the consumption of the mode in the industry R_{trans} in joules for 100 J of the energy content of ethanol E_{etoh} produced from the load. R_{trans} takes also into account the distance of shipment d and the weight of the load in E_{etoh}, w_{load}. Trucks, t_{trans} from 7 to 1.4 MJ$(t_{\mathrm{load}}\cdot\mathrm{km})^{-1}$, can present the best $\mathrm{R_{trans}}$, lower than 0.5 J for 100 J of ethanol, because of trips over small d (less than 100 km) and of low w_{load} (less than 0.04 $t_{\mathrm{load}}\cdot\mathrm{GJ}^{-1}{}_{\mathrm{etoh}}$ for farm inputs and ethanol). R_{trans} of the plant transport to the factory by trucks ranges to 3 J due to larger w_{load} (up to 0.56 $t_{\mathrm{load}}\cdot\mathrm{GJ}^{-1}{}_{\mathrm{etoh}}$ for sugar cane). Large part of the ethanol is moved from the factory to the local storages over 1000 km more or less depending on the proximity of consumption centres. Efficient modes such as pipeline and sea ships, $\mathrm{t_{trans}}$ as low as 0.05 MJ $(t_{\mathrm{load}}\cdot\mathrm{km})^{-1}$ when optimized, can compensate for these distances with R_{trans} around 1 J. R_{trans} to export ethanol from Brazil to France would represent less than 5 J, much lower than the difference of consumptions R between sugar cane and sugar beet based ethanol productions.

12/01312 Correlations and volatility spillovers between oil prices and the stock prices of clean energy and technology companies

Sadorsky, P. *Energy Economics*, 2012, 34, (1), 248–255.

In this paper, multivariate GARCH models are used to model conditional correlations and to analyse the volatility spillovers between oil prices and the stock prices of clean energy companies and technology companies. Four different multivariate GARCH models (BEKK, diagonal, constant conditional correlation, and dynamic conditional correlation) are compared and contrasted. The dynamic conditional correlation model is found to fit the data the best and generates results showing that the stock prices of clean energy companies correlate more highly with technology stock prices than with oil prices. On average, a $1 long position in clean energy companies can be hedged for 20 cents with a short position in the crude oil futures market.

12/01313 CO_2-based methanol and DME – efficient technologies for industrial scale production

Pontzen, F. *et al. Catalysis Today*, 2011, 171, (1), 242–250.

The conversion of CO_2 with H_2 to methanol (MeOH) over a commercial Cu/ZnO catalyst (Süd-Chemie, Germany) was studied under process conditions. The obtained results showed a good stability of the catalytic system and a large potential for a CO_2 emission reduction with simultaneous production of MeOH or dimethyl ether (DME) as bulk chemicals or alternative fuels. If H_2 is obtained from renewable or CO_2-neutral sources (e.g. biomass, solar, wind or nuclear energy), respectively, a potentially CO_2-neutral cycle is possible. Compared to the conventional synthesis gas based technologies like the Lurgi MegaMethanol® process, the CO_2-based process shows lower productivities. However, since the overall reaction is less exothermic, lower temperature peaks and lower byproduct contents are found at similar process conditions. The higher purity is beneficial for further chemical conversions, like the DME synthesis. In the Lurgi MegaDME® technology, DME is produced efficiently in terms of costs and energy demand and can be used as alternative fuel for diesel engines. The MegaDME technology, based on the Lurgi MegaMethanol® process, allows overall capacities of up to 1.5 Mio t a^{-1} DME in a single process train from syngas generation via Methanol synthesis, to DME synthesis and product purification without parallelized equipment.

12/01314 CREATIV: research-based innovation for industry energy efficiency

Tangen, G. *et al. Applied Thermal Engineering*, 2011, 31, (17–18), 3648–3652.

Improved energy efficiency is imperative to minimize greenhouse gas emissions and to ensure future energy security. It is also a key to continued profitability in energy consuming industry. The project CREATIV is a research initiative for industry energy efficiency focusing on utilization of surplus heat and efficient heating and cooling. In CREATIV, international research groups work together with key vendors of energy efficiency equipment and an industry consortium including the areas metallurgy, pulp and paper, food and fishery, and commercial refrigeration supermarkets. The ambition of CREATIV is to bring forward technology and solutions enabling Norway to reduce both energy consumption and greenhouse gas emissions by 25% within 2020. The main research topics are electricity production from low temperature heat sources in supercritical CO_2 cycles, energy efficient end-user technology for heating and cooling based on natural working fluids and system optimization, and efficient utilization of low temperature heat by developing new sorption systems and compact compressor-expander units. A defined innovation strategy in the project will ensure exploitation of research results and promote implementation in industry processes. CREATIV will contribute to the recruitment of competent personnel to industry and academia by educating doctoral and postdoctoral candidates and several master's students. The paper presents the CREATIV project, discusses its scientific achievements so far, and outlines how the project results can contribute to reducing industry energy consumption.

12/01315 Friction factors, convective heat transfer coefficients and the Colburn analogy for industrial sugarcane juices

Astolfi-Filho, Z. *et al. Biochemical Engineering Journal*, 2012, 60, 111–118.

Sugarcane (*Saccharum* sp.) is a relatively low-cost agricultural resource, produced mainly in tropical and subtropical regions of the planet. One of the most important applications of sugarcane juice is in the production of ethanol biofuel. A correct design of unit operations during the sugarcane juice processing requires an accurate characterization of the flow properties (friction factors, rheological behaviour, thermophysical properties and heat transfer coefficients) of this raw material. In this work, friction factors (f) and Nusselt number (Nu) were determined for sugarcane juice in different steps of its processing (untreated sugarcane juice, clarified sugarcane juice and mixed sugarcane juice). For both laminar and turbulent flows, the empirical models for f fitted well ($r^2 > 0.9$) with the experimental values obtained by pressure drop measurements. Also, Nu values calculated by applying the empirical correlation of Hausen (for laminar flow) and that of Sieder–Tate (for turbulent flow) presented good adjustment ($r^2 > 0.9$) to the experimentally determined values. Thus, the f and Nu values obtained for turbulent flow were taken to verify the Colburn analogy, which furnished results with small deviations ($\leq$8.9%) from the expected ideal value. This finding indicates the suitability of such analogy in this case, allowing good estimations of heat transfer coefficients from frictions factors, or vice versa, for sugarcane juices in turbulent flow conditions.

12/01316 Improved Taguchi method based contract capacity optimization for industrial consumer with self-owned generating units

Yang, H.-T. and Peng, P.-C. *Energy Conversion and Management*, 2012, 53, (1), 282–290.

Contract capacity setting for industrial consumer with self-owned generating units (SOGUs) is a highly discrete and non-linear optimization problem considering expenditure on the electricity from the utility and operation costs of the SOGUs. This paper proposes an improved Taguchi method that combines existing Taguchi method and particle swarm optimization (PSO) algorithm to solve this problem. Taguchi method provides fast converging characteristics in searching the optimal solution through quality analysis in orthogonal matrices. The integrated PSO algorithm generates new solutions in the orthogonal matrices based on the searching experiences during the evolution process to further improve the quality of solution. To verify feasibility of the proposed method, the paper uses the real data obtained from a large optoelectronics factory in Taiwan. In comparison with the existing optimization methods, the proposed improved Taguchi method has superior performance as revealed in the numerical results in terms of the convergence process and the quality of solution obtained.

12/01317 Modeling and optimization of an industrial hydrocracking unit to improve the yield of diesel or kerosene

Zhou, H. *et al. Fuel*, 2011, 90, (12), 3521–3530.

Hydrocracking is used in the petroleum industry to convert low-quality feedstocks into highly valued transportation fuels. This process is the best source of low-sulfur and low-aromatics diesel fuel as well as high-smoke point jet fuel. Many approaches have been proposed for solving optimization of hydrocracking units in the last decades, but they usually neglect the reaction in hydrotreater where hydrocarbon cracking often occurs, thus leading to suboptimal solutions in industrial problems. Unlike existing literature, this paper considers the hydrocarbon cracking reactions in hydrotreater and hydrocracker simultaneously. The models are based on energy balance, mass balance and a discrete lumped model approaches for kinetic modelling. Before optimization, the properties of feedstock are predicted with ASPEN PLUS by using laboratory data from the refinery, and then the model parameters are estimated with genetic algorithm (GA) based on industrial data and validated by comparing the simulating results with industrial data. To improve the yield of the lighter products, the operation conditions are optimized by GA and sequential quadratic programming (SQP). The yields of the diesel or kerosene increase with the proposed approach.

12/01318 Optimal design of plate-and-frame heat exchangers for efficient heat recovery in process industries

Arsenyeva, O. P. *et al. Energy*, 2011, 36, (8), 4588–4598.

The developments in design theory of plate heat exchangers, as a tool to increase heat recovery and efficiency of energy usage, are discussed. The optimal design of a multi-pass plate-and-frame heat exchanger with mixed grouping of plates is considered. The optimizing variables include the number of passes for both streams, the numbers of plates with different corrugation geometries in each pass, and the plate type and size. To estimate the value of the objective function in a space of optimizing variables the mathematical model of a plate heat exchanger is developed. To account for the multi-pass arrangement, the heat exchanger is presented as a number of plate packs with co- and counter-current directions of streams, for which the system of algebraic equations in matrix form is readily obtainable. To account for the thermal and hydraulic performance of channels between plates with different geometrical forms of corrugations, the exponents and coefficients in formulas to calculate the heat transfer coefficients and friction factors are used as model parameters. These parameters are reported for a number of industrially manufactured plates. The described approach is implemented in software for plate heat exchangers calculation.

12/01319 Performance analysis for glass furnace regenerator

Sardeshpande, V. *et al. Applied Energy*, 2011, 88, (12), 4451–4458.

Glass manufacturing is an energy intensive process where fossil fuel is used to maintain high temperature (about 1700 °C) for glass melting. Heat recovery from flue gas (1350–1500 °C) is usually in the form of combustion air pre-heating (900–1200 °C) using a regenerator. Dust from flue gas which is carried over from the furnace gets deposited in the regenerator storage matrix path. This leads to a deterioration of regenerator efficiency. A regenerator model is developed to estimate the actual performance of the regenerator and to compare it with the target performance. The proposed model is based on mass and energy balance of streams along with heat transfer characteristic equations. The model is illustrated for a 130 TPD (tons per day) furnace regenerator of an industrial glass plant at Mumbai, India. Model results for the regenerator studied indicate a blockage of 50% on the doghouse side and 22% on the non-doghouse side of the regenerator. The actual performance of the regenerator is found to be 7% lower than its target performance for the doghouse side regenerator. The model developed can also be used in other industrial sectors such as steel, chemical and so on.

12/01320 Potential of best practice technology to improve energy efficiency in the global chemical and petrochemical sector

Saygin, D. *et al. Energy*, 2011, 36, (9), 5779–5790.

The chemical and petrochemical sector is by far the largest industrial energy user, accounting for 30% of the industry's total final energy use. However, due to its complexity its energy efficiency potential is not well understood. This article analyses the energy efficiency potential on a country level if best practice technologies (BPT) were implemented in chemical processes. Two approaches are applied and an improved dataset referring to Europe has been developed for BPT energy use. This methodology has been applied to 66 products in fifteen countries that represent 70% of chemical and petrochemical sector's energy use worldwide. The results suggest a global energy efficiency potential of 16% for this sector, excluding savings in electricity use and by higher levels of process integration, combined heat and power and post-consumer plastic waste treatment. The results are more accurate than previous estimates. The results suggest significant differences between countries, but a cross-check based on two different methods shows that important methodological and data issues remain to be resolved. Further refinement is needed for target setting, monitoring and informing energy and climate negotiation processes. For the short and medium term, a combination of benchmarking and country level analysis is recommended.

12/01321 Study of elemental mercury re-emission in a simulated wet scrubber

Omine, N. *et al. Fuel*, 2012, 91, (1), 93–101.

Mercury is a toxic pollutant that has motivated environmental regulations for emissions reduction from coal-fired power plants. Acid gas wet scrubbers are known to provide the co-benefit of SO_2 control and mercury removal, when mercury is found in the flue gas in the oxidized form. The aqueous ionic chemistry in the scrubbing solution can lead to transformation of the absorbed ionic mercury to the insoluble elemental mercury form, resulting in mercury re-emission and a reduction of the scrubber mercury capture efficiency. Laboratory-scale experiments were performed in a simulated batch scrubber. The experiments were carried out to simulate a forced oxidation limestone reactor. The effect of scrubber temperature and pH, ionic mercury concentration in the liquor, total sulfite, and chloride and bromide ion concentration in solution, and O_2 and CO_2 concentration in the gas on mercury re-emission was investigated. Of particular interest was the investigation of the impact of slurry temperature and CO_2 concentration in the gas, under conditions typical of oxy-fuel combustion condition, on mercury re-emission. The results confirm that oxidized mercury is reduced by aqueous S(IV). Higher concentrations of sulfites, chloride and bromide ions inhibit oxidized mercury transformation to elemental mercury. Higher concentrations of ionic mercury in the liquor and increased scrubber temperature and pH value results in higher re-emission levels of elemental mercury. Additionally, on the impact of oxy-fuel conditions on mercury, it was found that high availability of excess oxygen in the flue gas in contact with the scrubbing solution was found to result in lower conversion of oxidized to elemental mercury. No impact from CO_2 in the flue gas was found on elemental mercury re-emission. However, higher slurry temperatures under oxy-fuel combustion conditions would lead to increased elemental mercury re-emission. For completeness, the effectiveness of sulfide-based additives for abatement of elemental mercury re-emission was also demonstrated in this study. The suppression effectiveness of sodium hydrogen sulfide, sodium sulfide, TMT15® and the Nalco-8034 reagent was found at 99%, 97%, 93% and 99%, respectively. These additives promote precipitation of ionic mercury as mercury sulfide.

12/01322 System analysis in a European perspective of new industrial cooling supply in a CHP system

Svensson, I.-L. and Moshfegh, B. *Applied Energy*, 2011, 88, (12), 5164–5172.

In the municipality of Södertälje two large industries use much of the electricity, district heating (DH) and chilled water in the area. The Södertälje energy system is not isolated, however, but is connected to the DH systems of southern and central Stockholm, and a change in the Södertälje energy system will also influence the connected energy systems in Stockholm. The cooling demand in Södertälje is currently covered by lake water cooling and compression chillers, but in order to reduce the use of electricity, conversion to absorption cooling or increased lake water cooling can be considered. The large combined heat and power (CHP) plant in Södertälje is not used to its full potential today, but investment in absorption cooling and/or a cold condenser unit integrated with the CHP plant could increase the plant's operation hours. In this paper the system effects of introducing new industrial cooling supply in Södertälje has been investigated through optimizations of a model including both the industries and the district heating supply in Södertälje and Stockholm. The results show that, independently of whether condensing power production is feasible in the CHP plant or not, investments in both increased lake water cooling and absorption cooling are profitable. A sensitivity analysis of how energy market prices affect the results shows that even though the system cost will change depending on energy market prices, the optimum cooling technology mix will remain the same. However, a sensitivity analysis of the transfer DH capacity between the Södertälje and Stockholm energy systems shows that if the transfer DH capacity is increased, absorption cooling will be less profitable since more heat can be sold from Södertälje to Stockholm while at the same time reducing the use of fuel resources.

12/01323 Targeting for energy efficiency and improved energy collaboration between different companies using total site analysis (TSA)

Hackl, R. *et al. Energy*, 2011, 36, (8), 4609–4615.

Rising fuel prices, increasing costs associated with emissions of greenhouse gases and the threat of global warming make efficient use of energy more and more important. Industrial clusters have the potential to significantly increase energy efficiency by energy collaboration. In this paper Sweden's largest chemical cluster is analysed using the total site analysis (TSA) method. TSA delivers targets for the amount of utility consumed and generated through excess energy recovery by the different processes. The method enables investigation of opportunities to deliver waste heat from one process to another using a common utility system. The cluster consists of five chemical companies producing a variety of products, including polyethylene (PE), polyvinyl chloride (PVC), amines, ethylene, oxygen/nitrogen and plasticizers. The companies already work together by exchanging material streams. In this study the potential for energy collaboration is analysed in order to reach an industrial symbiosis. The overall heating and cooling demands of the site are around 442 and 953 MW, respectively. There is 122 MW of heat is produced in boilers and delivered to the processes. TSA is used to stepwise design a site-wide utility system which improves energy efficiency. It is shown that heat recovery in the cluster can be increased by 129 MW, i.e. the current utility demand could be completely eliminated and further 7 MW excess steam can be made available. The proposed retrofitted utility system involves the introduction of a site-wide hot water circuit, increased recovery of low pressure steam and shifting of heating steam pressure to lower levels in a number heat exchangers when possible. Qualitative evaluation of the suggested measures shows that 60 MW of the savings potential could to be achieved with moderate changes to the process utility system corresponding to 50% of the heat produced from purchased fuel in the boilers of the cluster. Further analysis showed that after implementation of the suggested energy efficiency measures there is still a large excess of heat at temperatures of up to 137 °C.

12/01324 Targeting the optimum steam system for power generation with increased flexibility in the steam power island design

Botros, B. B. and Brisson, J. G. *Energy*, 2011, 36, (8), 4625–4632.

The importance of the steam cycle design to maximize power generation is demonstrated using pinch analysis targeting techniques is demonstrated. Fixed steam headers, such as assumed in total site analysis, give no allowance for reheating before turbine expansion, which can be valuable to consider when optimizing the steam system for certain plant configurations. Additionally, previous work optimizes the steam pressure level based on its saturation temperature alone. The present work examines the effect of including both sensible and latent heating of steam in the balanced composite curve. It is shown that including sensible heating allows for better thermal matching between the process and steam system which results in improving the overall efficiency while minimizing cost. A case study using an IGCC plant with CCS is analysed to assess changes in steam cycle design on the plant efficiency and cost.

12/01325 The performance of industrial sector voluntary climate programs: Climate Wise and 1605(b)

Pizer, W. A. *et al. Energy Policy*, 2011, 39, (12), 7907–7916.

Corporate voluntary climate programs have had limited evaluation. The self-selection of participants – an essential element of such initiatives – poses challenges to researchers because the decision to participate may not be random and may be correlated with outcomes. This study aims to gage the environmental effectiveness of the industrial sector elements of two early voluntary climate change programs with established track records, the US Environmental Protection Agency's Climate Wise and the US Department of Energy's Voluntary Reporting of Greenhouse Gases Program (1605(b)). Particular attention is paid to the participation decision and how various assumptions affect estimates of program outcomes using propensity score matching methods applied to plant-level Census data. Overall, the effects are modest: reductions in fuel and electricity expenditures are no more than 10% and probably less than 5%. Virtually no evidence suggests either program has a statistically significant effect on fuel costs. Some evidence indicates that participation in Climate Wise led to a 3–5% increase in electricity costs that vanished after 2 years. Stronger evidence suggests that participation in 1605(b) led to a 4–8% decrease in electricity costs that persisted for at least 3 years. These results suggest that while voluntary programs can play some role in addressing climate change, they are unlikely to bring about the kinds of steep reductions called for in the current debate.

10 SPACE HEATING AND COOLING/HEAT PUMPS

12/01326 A new scheme for cooling tower water conservation in arid-zone countries

Al-Bassam, E. and Maheshwari, G. P. *Energy*, 2011, 36, (7), 3985–3991.

Cooling towers (CTs) that are used for heat rejection in water-cooled (WC) systems consume a large quantity of water, which is generally not available naturally. CTs are selected when the maximal cooling load is desired and under the worst design conditions. Typically, CTs operate under partial-load conditions and/or favourable weather conditions. Moreover, for most of the summer season, the dry bulb temperature (DBT) of the incoming ambient air is significantly greater than the incoming hot water temperature, and the air undergoes sensible cooling. Currently, the control scheme that is commonly used in most CTs maintains a constant exiting water temperature for different cooling loads and a different ambient wet bulb temperature (WBT) by regulating the air circulation through the CT. The air circulation is reduced with the help of a variable frequency drive (VFD), which results in a significant reduction in the fan power of the CT. This paper presents an assessment of CT performance with a VFD application using a computer simulation program and illustrates a proposed scheme for maximal water savings. These theoretical results demonstrated that reducing the air flow by applying a VFD in a CT can achieve at least a 25% reduction in water consumption.

12/01327 A new type of district heating system based on distributed absorption heat pumps

Li, Y. *et al. Energy*, 2011, 36, (7), 4570–4576.

Large district heating (DH) system accounts for 70% of urban building heating in China. In north China, this proportion is even higher (the north of China is north of the Huai River and Qinling mountains). Many cities in north China can exploit various kinds of low-grade renewable energy. This paper presents a new heating method to realize renewable energy recovery by absorption heat pumps associated with municipal network. In the DH substations, absorption heat pumps are driven by the exergy-difference originated from the larger temperature difference of heat exchange between primary and secondary heat network. There are two configurations: type I and type II substations based on the temperature of renewable energy. A reasonable parameter setting of system is suggested. The equipment operational performance was optimized based on a practical example. The low-grade renewable energy can be recovered effectively in this method. As a result, both heating capacity and energy efficiency of the DH system can be improved. Furthermore, operating costs may be reduced remarkably, due to the reduction in both the coal consumption of heat production unit and the power consumption of delivery pump. Therefore, the system is superior in energy conservation and has a promising application prospect.

12/01328 A review of natural convective heat transfer correlations in rectangular cross-section cavities and their potential applications to compound parabolic concentrating (CPC) solar collector cavities

Singh, H. and Eames, P. C. *Applied Thermal Engineering*, 2011, 31, (14–15), 2186–2196.

Natural convective heat transfer in cavities is a complex function of cavity shape, aspect ratio, boundary conditions at the walls and the properties of the fluid contained within the enclosure. Considerable research into natural convection in regular shaped cavities, such as those of rectangular, square cross-section, or cylindrical annuli has been undertaken. Knowledge is, however, more limited relating to natural convective heat transfer in compound parabolic concentrating (CPC) solar collector cavities. Accurate knowledge of the variation in local convective heat transfer coefficients at the different CPC cavity components would facilitate to the design of suitable convection suppression devices, for example baffles at specific locations within the cavity, substantially reducing convective heat transfer and thus improving the performance of CPC solar collectors. From analysis of the correlations developed for regularly shaped enclosures it is concluded that the employment of these correlations to describe natural convection in CPC solar collector cavities can be misleading.

12/01329 A techno-economic analysis of small-scale, biomass-fuelled combined heat and power for community housing

Wood, S. R. and Rowley, P. N. *Biomass and Bioenergy*, 2011, 35, (9), 3849–3858.

This paper presents the results of a techno-economic study into the feasibility of a number of biomass-fuelled CHP (BCHP) systems when operated in a community housing/mixed use context. Six systems comprising differing technologies have been analysed, with the assumption that the systems operate within an ESCO (energy services company) supply scenario. Actual demand data was obtained for a representative community housing scheme, along with technical performance and cost data on the various biomass CHP systems. Subsequently, an economic modelling tool was developed and a number of operational scenarios were analysed to determine the viability of specific systems and the sensitivity of the results to a range of technical and economic parameters. The impact of thermal storage was also considered in order to optimize heat usage as far as possible. The results indicate that within specific realistic ESCO operating scenarios, biomass CHP can demonstrate positive net present values without the need for capital subsidies. Optimal system design and implementation is critical for profitable operation and it is found that the best economic performance occurs for high load factors when the maximum quantity of both electricity and heat sold on-site is maximized. The results are also found to be very sensitive to a number of the model inputs.

12/01330 Applicability of infrared thermography to the study of the behaviour of stone panels as building envelopes

Cerdeira, F. *et al. Energy and Buildings*, 2011, 43, (8), 1845–1851.

Thin stone wall cladding systems used on exterior building envelopes typically consist of stone panels made of granite. There is a risk of detachment if the cement used to stack the panels is defective. There is a wide range of destructive techniques to evaluate the state of the facades, but they are scarcely practical. Infrared thermography (IRT) offers a cost-effective alternative to traditional evaluation. The sizes and shapes of the defects detected by this methodology in the cement holding the panels are presented in order to evaluate the capacity of the aforementioned technique.

12/01331 Area ratio effects to the performance of air-cooled ejector refrigeration cycle with R134a refrigerant

Yan, J. and Cai, W. *Energy Conversion and Management*, 2012, 53, (1), 240–246.

In this paper, the key ejector geometry parameters for an air-cooled ejector cycle using R134a with cooling capacity of 2 kW are designed by one-dimensional analysis. Through enlarging the designed area ratios by connecting the replaceable nozzles with a main body, optimum area ratios under air-conditioning working conditions are studied experimentally. Three parameters, namely, the entrainment ratio, coefficient of performance and cooling capacity are evaluated, and the results show that the optimum area ratios are from 3.69 to 4.76 that are lower than those mentioned in other studies. With a fixed area ratio, experiments also show that the influence of the ejector area ratio on the ejector performance largely depends on the operating conditions. Consequently, the effects of operating conditions such as primary flow pressures on the ejector system performance are evaluated.

12/01332 Assessment of high temperature organic Rankine cycle engine for polygeneration with MED desalination: a preliminary approach

Maraver, D. *et al. Energy Conversion and Management*, 2012, 53, (1), 108–117.

The objective of this paper is to assess a proposed simultaneous energy and water generation system through a main combination of technologies: organic Rankine cycle (ORC) for heat and power generation, multi-effect distillation (MED) water desalination and a cold generation thermally activated technology (TAT). It is also a primary objective the performance evaluation of the ORC subsystem applied to the use of high temperature renewable energy sources to activate the proposed configuration. This study is divided into three main sections. First of all, the energy feasibility of the proposed configuration is analysed through the fuel energy saving ratio (FESR) in order to determine the optimal distribution of the heat generated by the prime mover, i.e. the ORC, obtaining that the highest savings correspond to the complete use of heat for domestic hot water (DHW) or heating, which limits the amount of heat used for the activation of MED and TAT subsystems only up to 40%, when the polygeneration system is compared with a high-performance stand-alone one. In addition, the ORC subsystem was modelled using the Aspen Plus process simulator, while heat to MED unit was simulated as an input of the model. This part of the paper analyses a comprehensive list of candidate working fluids for the ORC polygeneration application, and a selection was made of the most interesting according to the preliminary conclusions extracted from the first section of this paper: fluorobenzene and octamethyltrisiloxane could be the most suitable organic fluids for the proposed system. The third main section of this paper deals with the liability of the proposed polygeneration configuration activated by biomass thermal oil boilers through a techno-economic evaluation, revealing that approximate payback periods between 4 and 20 years might be obtained for biomass prices and MED engine specific investment cost in the range of 0–200 €/t and 0–15,000 €/m^3/day, respectively. The main conclusions extracted from the paper results reveal that the amount of heat generated in the ORC condenser used for desalination severely limits the primary energy savings in comparison to conventional systems, as well as the electric efficiency obtained with every single fluid. In consequence, the working fluids that might be used in order to obtain a valid FESR and an assumable economic performance for investors are limited. The importance of the proposed configuration activated by biomass combustion lies in the well-known environmental advantages of this renewable resource, plus the energy advantages from the efficiency point of view (despite the lower efficiency of the subsystems in comparison with internal combustion engines or compression chillers) proving that it is possible to achieve small scale water desalination and electricity, cold and heat generation with energy savings in comparison with conventional systems.

12/01333 Comparison of T-junction flow pattern of water and sodium for different geometries of power plant piping systems

Nematollahi, N. and Khonsha, B. *Annals of Nuclear Energy*, 2012, 39, (1), 83–93.

The history of nuclear power plants (NPPs) experiences (such as Phenix NPP and Tomari NPP) shows the failure of the piping systems particularly at T-junction area with an elbow on the upstream. With regard to catastrophic consequences of piping break in the nuclear power plants and radioactive material release to the environment, it is essential to have reliable piping systems. For this purpose, several geometries and parameters are considered. For model validation the available experimental data for the water is compared with the results, which show very good agreement. The same procedure is carried out with the water and sodium for the dimensions of the failed T-junction in Phenix piping system. The change effects in the physical properties from the water to the sodium in a T-junction area with an elbow on the upstream are compared. Next, classifications of the sodium mixing jets are presented. Also the temperature and velocity patterns of the sodium in the two types of geometries like S and E, with three different dimensionless distances, are simulated. Finally, the most reliable geometry, minimum appropriate dimensionless distance and optimum mixing jet type are determined. The important parameters of these simulations are momentum ratio, dimensionless distance and velocity ratio. The results will be used to promote design and enhance the safety and reliability of the piping systems in nuclear power plants.

12/01334 Contribution to analytical and numerical study of combined heat and moisture transfers in porous building materials

Abahri, K. *et al. Building and Environment*, 2011, 46, (7), 1354–1360.

In this paper, one-dimensional model for evaluating coupled heat and moisture transfer in porous building materials was proposed. The transient partial differential equations system was solved analytically for Dirichlet boundary conditions. It consists first to introduce the Laplace transformation and then to use the potential function technique. This approach allows simplifying the initial mathematical problem to a fourth order ordinary differential equation which can be easily solved. This solution was used to assess the transient temperature and moisture distribution across materials.

12/01335 Daylighting and energy analysis of private offices with automated interior roller shades

Shen, H. and Tzempelikos, A. *Solar Energy*, 2012, 86, (2), 681–704.

This paper presents a comprehensive analysis to study the balance between daylighting benefits and energy requirements (control of solar gains) in perimeter private office spaces with interior roller shades taking into account glazing properties, shading properties and control together with window size, climate and orientation in an integrated daylighting and thermal manner. Daylight autonomy and useful daylight illuminances were computed as a function of façade design parameters. A thermal simulation module using the explicit finite difference thermal network approach runs at the same time step and calculates heating, cooling and lighting source energy consumption as well as surface temperatures and operative temperature. Based on the daylighting results, lighting internal gains (continuous dimming control) are simultaneously input to the thermal module. The model also considers the air in the gap between shade and interior glass as a separate thermal node. Detailed results for Chicago and Los Angeles showed that windows with visible transmittance higher than 50% have the ability to allow enough daylight into the space for all locations and orientations for window-to-wall ratios higher than 50%. Useful daylight illuminances between 500 and 1000 lux were considered in detail – it was found that this index can be maximized for specific window-to-wall ratios and that depends on the glazing properties and fabric properties for each orientation. Moreover, the complex interactions of the studied parameters and their impact on the heating, cooling and lighting energy performance revealed an interesting result: windows occupying 30–50% of the façade can actually result in lower total energy consumption for most cases with automated shading. This illustration of daylighting benefits can be realized only if the integration of daylighting and thermal climate-based analysis is modelled efficiently and depends on glazing and shading properties and control. Finally, best designs for each orientation and location were pointed out based on both daylighting and thermal results.

12/01336 Design of a high power heater for the cryogenic hydrogen system at J-PARC

Tatsumoto, H. *et al. Cryogenics*, 2011, 51, (6), 315–320.

The cryogenic hydrogen system, which provides the supercritical hydrogen with the pressure of 1.5 MPa and the temperature of around 20 K, adopts to moderate and convert high-energy neutrons into cold neutrons for neutron scattering experiments in the J-PARC. Large pressure fluctuation caused by the intense pulsed-proton-beam injection and trip should be mitigated by both an active heater control and a passive accumulator control. A compact high power heater should be required to compensate the heat load corresponding to the nuclear heating while the proton beam stopping. In this study, the high power heater used in the cryogenic hydrogen was designed and a numerical analysis was performed. Then the results confirmed that the heater could apply kW-order heat powers to supercritical hydrogen without any disturbance.

12/01337 Development and characterization of paraffin-based shape stabilized energy storage materials

Ehid, R. and Fleischer, A. S. *Energy Conversion and Management*, 2012, 53, (1), 84–91.

The passive nature of energy storage through phase transition makes phase change materials (PCMs) a reliable choice for many applications. Shape-stabilized phase change materials (PCMs) mix liquid PCM with a molten polymer to create a material in which the PCM is fully contained even above the melt temperature of the PCM. Since the energy storage in the material will be a function of the amount of PCM, it is desirable to shape stabilize the material with as little polymer as possible. It is also important to understand the physical strength of these materials if they are to be used without a containment structure. Therefore, this study experimentally characterizes the structural and thermal properties of SS-PCM, identifies the effects of changing polymer loading level, provides guideline to determine at what point the material becomes shape-stabilized, and determines the heating and cooling curves. Based on these tests, it can be concluded that a sample of PCM can be considered to be shape-stabilized when the loading level of polymer creates a sample with structural integrity above the melting point, with geometric stability including elimination of contraction upon solidification and a sample with no circulation of the PCM during the melt phase, as well as full containment of the melt. For the samples investigated here, shape stabilization occurs in paraffin/HDPE mixtures above 25–30% HDPE.

12/01338 Effect of brine flow rate on the performance of a spiral-jacketed thermal storage tank used for SDHW systems: a computational fluid dynamics study

Baek, S. M. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2716–2725.

This study numerically investigates the effect of the brine flow rate on the thermal performance of a spiral-jacketed thermal storage tank (TST) installed in a solar domestic hot water (SDHW) system. The spiral-jacketed TST is a TST with a mantle heat exchanger, consisting of a vertical, cylindrical water tank for energy storage and a spiral brine flow path attached to the tank wall for heat transfer. A computational fluid dynamics (CFD) model was constructed based on the actual geometry of a spiral-jacketed TST. In addition, the boundary conditions were defined by considering solar radiation and ambient temperature data that were measured during experimental operation of the SDHW system. The numerical results demonstrated that an increase in the brine flow rate enhances the thermal efficiency of the TST due to higher heat transfer coefficients in the spiral path, and also leads to reduced thermal stratification in the TST. On the other hand, a lower brine flow rate increased the heat transfer rate at the inlet of the spiral path near the top of the TST, which resulted in enhanced thermal stratification. The optimal range for the rate of brine flow rate is discussed with respect to the thermal efficiency of the TST and the required pumping power for brine circulation in the spiral flow path.

12/01339 Energy and cost evaluation of thermal bridge correction in Mediterranean climate

Evola, G. *et al. Energy and Buildings*, 2011, 43, (9), 2385–2393.

In the cold climate of continental Europe the correction of thermal bridges in buildings is a mandatory issue, as in these areas they produce not only heat losses but frequently also condensation and mould growth. In mild Mediterranean climate thermal bridges also cause an increase in energy consumption, but usually do not present condensation effects. In Italy, the current regulations for new buildings only recommend but do not impose the thermal bridge correction, which usually needs extra costs during construction and refurbishment phases. This paper presents a study on the effects of thermal bridges for two building types (terraced houses and semi-detached houses) and three current envelope solutions in Italian climate, which may be considered representative of mild Mediterranean climate. The buildings are characterized by reinforced concrete frameworks and clay block walls; the thermal performance of the envelopes complies with Italian regulations for new constructions. In a first step the impact of thermal bridges on both heating and cooling energy demand is studied; then the economic convenience of correcting such thermal bridges is assessed by calculating the discounted payback period referred to the additional costs of construction and refurbishment.

12/01340 Energy efficient surfaces on building sandwich panels – a dynamic simulation model

Joudi, A. *et al. Energy and Buildings*, 2011, 43, (9), 2462–2467.

The choice of building envelope is critical for the energy performance of buildings. The major part of the energy used by a building during its lifetime is used for maintaining a suitable interior thermal climate under varying exterior conditions. Although exterior heat radiation properties (i.e. total solar reflectivity and long wave thermal emissivity) have been well accepted to have a large impact on the need for active cooling in warmer climate, the effect of a reduced thermal emissivity on interior surfaces on the building thermal energy flux is rarely studied. This paper addresses the sensitivity of the thermal energy flux through a sandwich panel, by systematically varying the surface thermal emissivity (both interior and exterior) and total solar reflectance of exterior surface, for three geographical locations: southern, middle and northern Europe. A model is introduced for calculating the effect of both interior and exterior optical properties of a horizontal roof panel in terms of net energy flux per unit area. The results indicate potential energy saving by the smart choice of optical properties of interior and exterior surfaces.

12/01341 Establishment and solution of the model for loop pipeline network with multiple heat sources

Jie, P. *et al. Energy*, 2011, 36, (9), 5547–5555.

The district heating system (DHS) can effectively save energy, so it has been widely used and promoted on a global scale. There are still a series of problems. In order to improve the problem of high energy consumption during transportation, it is necessary to study the hydraulic characteristics of DHS. Through the survey of DHS in different cities, it was found that the form of the heating network was toward a loop pipeline network (LPN) with multiple heat sources. Previous hydraulic models of the dendritic pipeline network (DPN) were expressed. As for LPN with multiple heat sources, deficiencies of treatment were analysed. It was pointed out that LPN with multiple heat sources was a spatial network. Graph theory was applied to the establishment of the spatial network. And the hydraulic model of LPN with multiple heat sources was established. MKP was used to solve the mathematical model. The actual engineering case was used to verify the accuracy of the model and its solution method, which provided a theoretic and practical basis for the study of the hydraulic characteristics of the DHS.

12/01342 Heat transfer performance of cryogenic oscillating heat pipes for effective cooling of superconducting magnets

Natsume, K. *et al. Cryogenics*, 2011, 51, (6), 309–314.

The cryogenic oscillating heat pipe (OHP) for conduction cooling of superconducting magnets was developed and the function was demonstrated successfully. OHP is a highly efficient heat transfer device using oscillating flow of two-phase mixture. The working fluids that are employed in the present research are Nitrogen, Neon and Hydrogen, and the operating temperatures are 67–91 K, 26–34 K and 17–27 K, respectively. The estimated effective thermal conductivities from the measurement data of the OHP were higher than one of the solids such as copper at low temperature. These results revealed that the cryogenic OHP can enhance the performance of cooling system for magnets.

12/01343 Immersion cooling nucleate boiling of high power computer chips

El-Genk, M. S. *et al. Energy Conversion and Management*, 2012, 53, (1), 205–218.

This paper presents experimental results of saturation and subcooled boiling of FC-72 and HFE-7100 dielectric liquids on uniformly heated, 10×10 mm porous graphite (PG) surfaces for potential applications to immersion cooling of high power computer chips. The experiments investigated the effects of surface inclination, from upward-facing (0°) to downward-facing (180°), and liquid subcooling from 0 to 30 K on nucleate boiling heat transfer coefficient and critical heat flux. The presented experimental data and correlations for natural convection of dielectric liquids on PG and plane surfaces are important for cooling chips while in the standby mode when surface heat flux $<20\,\mathrm{kW/m^2}$. The experimental curves of the nucleate boiling heat transfer coefficient for FC-72 dielectric liquid in the upward-facing orientation are used in three-dimensional thermal analysis for sizing and quantifying the performance of copper, PG and PG–Cu composite spreaders for removing the dissipated thermal power by an underlying 10×10 mm computer chip with non-uniform heat dissipation. The 2 mm-thick spreaders are cooled by either saturation or 30 K subcooled nucleate boiling of FC-72 and the composite spreader consists of 0.4 mm-thick surface layer of PG and 1.6 mm thick copper substrate.

12/01344 Impact of shape of container on natural convection and melting inside enclosures used for passive cooling of electronic devices

El Omari, K. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 3022–3035.

The present paper numerically analyses a passive cooling system using enclosures with different geometries filled with thermal conductivity-enhanced phase change material (PCM). A numerical code is developed using an unstructured finite-volume method and an enthalpy-porosity technique to solve for natural convection coupled to a solid–liquid phase change. Five geometries containing the same volume of PCM are compared while cooling the same surface. The unsteady evolution of the melting front and the velocity and temperature fields is detailed. Other indicators of cooling efficiency are monitored, including the maximum temperature reached at the cooled surface. The computational results show the high impact of varying geometry: a maximum temperature difference as high as 40 °C is observed between two of the enclosures. The best efficiency is obtained for an enclosure shifted vertically relative to the cooled surface. Other findings and recommendations are made for the design of PCM-filled enclosures.

12/01345 Improving evaluation of the heat losses from arrays of pipes or electric cables buried in homogeneous soil

de Lieto Vollaro, R. *et al. Applied Thermal Engineering*, 2011, 31, (17–18), 3768–3773.

The evaluation of the heat loss from finite arrays of horizontal buried cylinders is very interesting for many practical applications. A considerable effort has been done in the field of the electrical engineering to develop methods for calculating the thermal flux from the cables system to the ground surface through the soil. Nevertheless, the modelling hypothesis currently assumed for the case of arrays of a finite number of pipes and cables, introduces approximations that can involve inaccuracies in calculation. In this paper the extent of such inaccuracies is investigated by numerical techniques. Results show that the thermal resistance value of the worst refrigerated cylinder, obtained from numerical simulation, can result even 60% higher than the value calculated with standard IEC–IEEE method, while the thermal resistance of the whole array does not differ from the value obtained with the standard IEC–IEEE calculation method. Some correlating equations to obtain more accurate results in the thermal resistance calculation for the worst refrigerated cylinder are proposed.

12/01346 Influence of the management strategy and operating conditions on the performance of an adsorption chiller

Sapienza, A. *et al. Energy*, 2011, 36, (9), 5532–5538.

The aim of this experimental work was to study the influence of the operation mode (i.e. cycle time and relative duration of adsorption/desorption phases, R) as well as of the operating conditions on the performance of an adsorption chiller. The testing campaign demonstrated that the management optimization strongly improves the performance of such kind of machines. The coefficient of performance (COP) and the specific/volumetric cooling power (SCP, VCP) vary, respectively, in a range of ±133% and ±43% when the cycle time (τ_{cycle}) increases from 5 to 20 min at fixed boundary conditions ($T_e = 15\,°\mathrm{C}$, $T_c = 35\,°\mathrm{C}$, $T_h = 90\,°\mathrm{C}$) while a further increasing in performance (up to 15%) is reached, at fixed cycle time, by protracting the duration of the adsorption phase at the expense of the desorption one. The complete set of results allowed to draw a map of performance suitable for the optimization of the management mode taking into account the specific application. At $T_e = 15\,°\mathrm{C}$, $T_c = 35\,°\mathrm{C}$, $T_h = 90\,°\mathrm{C}$, if high SCP is required (e.g. automotive air conditioning), the optimal choice is $\tau_{\mathrm{cycle}} = 7$ min and $R = 2.5$ (SCP = 394 W/kg, COP = 0.60, VCP = 223 $\mathrm{W/m^3}$) while to assure a good efficiency (e.g. solar cooling) the proper management is $\tau_{\mathrm{cycle}} = 20$ min and $R = 1$ (SCP = 204 W/kg, COP = 0.69, VCP = 116 $\mathrm{W/m^3}$).

12/01347 Investigations on the role of mixed convection and wall friction factor in single-phase natural circulation loop dynamics

Kumar, N. *et al. Annals of Nuclear Energy*, 2011, 38, (10), 2247–2270.

The objective of the present paper is to present a one-dimensional (1-D) model for simulating the start-up from rest of water cooled single-phase natural circulation loops having horizontal heaters. The starting point of analysis is the inability of the 1-D codes to account for natural convection in the heater. Present 1-D models are unable to account for axial diffusion in the fluid caused by natural convection. Start-up from rest and many other characteristics cannot be simulated using classical 1-D models because of the inherent tendency of the predicted dynamics to be attracted by zero flow condition. The paper presents an elegant approach for taking into account both natural and forced convection. The enhancement of fluid motion and thermal mixing by natural convection is an important consideration in the design of nuclear reactors. Hence, the model developed is of direct relevance to nuclear reactor thermal hydraulics. The model developed for natural convection has been validated against the CFD simulations. The model developed has been incorporated in a classical 1-D model developed by the authors previously. The application of model to a rectangular single-phase natural circulation loop show that the model can predict the loop behaviour from start-up with fidelity. The model reproduces most of the characteristics like unidirectional oscillation, bidirectional oscillations and chaotic switching reasonably well. Finally, model has been used to investigate the phenomenon of hysteresis observed in experimental loop. The paper also brings out the role of constitutive laws for wall friction in predicting the loop dynamics.

12/01348 Loss analysis of thermal reservoirs for electrical energy storage schemes

White, A. J. *et al. Applied Energy*, 2011, 88, (11), 4150–4159.

The paper presents an analysis of thermodynamic losses in thermal reservoirs due to irreversible heat transfer and frictional effects. The focus is upon applications to large-scale electricity storage for which it is the loss in availability (or exergy) that is most relevant. Accordingly, results are presented as loss coefficients which are defined as the fractional loss of the entering availability. Only losses stemming from irreversibility are considered – heat losses to the surroundings are not included in the analysis. A number of simplifying assumptions have been adopted, but the results nonetheless clearly demonstrate the dependence of the losses on operating temperatures, reservoir geometry and mode of operation, and point the way towards methods of optimization. Estimates for a typical installation suggest that the losses are not insignificant, particularly for one-off charge and discharge (i.e. for long-term storage), but remain acceptable for cyclic operation, so as to make the use of thermal reservoirs attractive for electricity storage schemes.

12/01349 Natural convection in a horizontal channel provided with heat generating blocks: discussion of the isothermal blocks validity

Mouhtadi, D. *et al. Energy Conversion and Management*, 2012, 53, (1), 45–54.

This work presents a numerical study of air natural convection in a horizontal channel provided with heating blocks periodically distributed on its lower adiabatic surface. The blocks are submitted to a uniform heat generation and the channel upper surface is maintained at a cold constant temperature. The main objective of this study is to examine the validity of the model with isothermal blocks for the system under consideration. Then the calculations are performed using two different models. In the first (denoted model 1) the calculations are performed by imposing a uniform volumetric heat generation inside the blocks. In the second model (denoted model 2), the blocks are maintained isothermal at the average blocks surface temperature deduced from model 1. The controlling parameters of the present problem are the thermal conductivity ratio of the solid block and the fluid ($0.1 \le k^* = k_s/k_a \le 200$) and the Rayleigh number ($10^4 \le Ra \le 10^7$). The validity of the isothermal model is examined for various Ra by using criteria based on local and mean heat transfer characteristics. It is found that some solutions of the isothermal model do not reproduce correctly the results of the first model even for very large conductivity ratios. The Biot number below which model 2 is valid depends strongly on the Rayleigh number and the type of solution.

12/01350 Numerical modeling of slinky-coil horizontal ground heat exchangers

Fujii, H. *et al. Geothermics*, 2012, 41, 55–62.

Horizontal ground heat exchangers have been widely used in many countries as the heat source for ground-source heat pump systems. When abundant land space is available for the installation of ground heat exchangers, the horizontal ground heat exchangers provide a cost-effective choice because the installation costs of horizontal ground heat exchangers are much lower than those of vertical ground heat exchangers. Slinky-coil horizontal ground heat exchangers, which are basically coiled ground heat exchangers, require less land space than conventional straight horizontal ground heat exchangers because of the higher installation density of heat exchange pipes per given area. However, at present, the slinky-coil horizontal ground heat exchangers tend to be over- or undersized because of the lack of an appropriate design method for them. In this research on the optimum design of slinky-coil horizontal ground heat exchangers, a commercial finite-element simulator, FEFLOW, was used to simulate the performance of slinky-coil horizontal ground heat exchangers taking into account the energy balance at the land surface. The accuracy of the developed simulation model was validated through history-matching calculations on the basis of the results of thermal response tests and a long-term air-conditioning test under various test conditions. In history matching, reasonable agreement was obtained between the measured and simulated values of the heat medium and ground temperatures, demonstrating the reliability of the developed numerical simulation model using FEFLOW.

12/01351 Performance analysis of a two-stage thermal energy storage system using concrete and steam accumulator

Bai, F. and Xu, C. *Applied Thermal Engineering*, 2011, 31, (14–15), 2764–2771.

This paper presents a thermal analysis of a two-stage thermal energy storage system, in which concrete is used in the high-temperature heat storage stage and steam accumulator is used in the low-temperature stage. To analyse the thermal characteristics of the whole system, a numerical simulation model for the two-stage thermal storage system was developed, based on the conservation principle of mass and energy. The results show that the performance of the high-temperature concrete storage unit depends greatly on the concrete conductivity and the distance between the neighbouring steel tubes. Also, the steam discharging speed of steam accumulator directly affects the heat behaviour inside the concrete block. The founded simultaneous decline in the energy quality level for the steam accumulator and the concrete system may benefit cascade utilization of thermal energy. Results of the investigation will assist in the optimum design of the thermal energy storage system used for solar thermal power plant.

12/01352 Performance of straw bale wall: a case of study

Ashour, T. *et al. Energy and Buildings*, 2011, 43, (8), 1960–1967.

This research aimed to evaluate a straw bale house located in Bavaria, Germany. An extensive test program was carried out. The experimental work includes compression tests, moisture content, thermal stability of bales and pH. The *in situ* work includes temperature and relative humidity inside the straw bale wall. The stress–strain behaviour of straw bales was investigated including non-linearity and anisotropy. Thermal stability of bales under constant temperature and relative humidity was studied considering time dependence. The moisture content of straw bale was about 11%, while pH value inside the bale was about 7.29. Moreover, the temperature and the relative humidity between the interior (inside straw bale wall) and the exterior were investigated.

12/01353 Potential benefits of solar reflective car shells: cooler cabins, fuel savings and emission reductions

Levinson, R. *et al. Applied Energy*, 2011, 88, (12), 4343–4357.

Vehicle thermal loads and air conditioning ancillary loads are strongly influenced by the absorption of solar energy. The adoption of solar reflective coatings for opaque surfaces of the vehicle shell can decrease the ‘soak’ temperature of the air in the cabin of a vehicle parked in the sun, potentially reducing the vehicle’s ancillary load and improving its fuel economy by permitting the use of a smaller air conditioner. An experimental comparison of otherwise identical black and silver compact sedans indicated that increasing the solar reflectance (ρ) of the car’s shell by about 0.5 lowered the soak temperature of breath-level air by about 5–6 °C. Thermal analysis predicts that the air conditioning capacity required to cool the cabin air in the silver car to 25 °C within 30 min is 13% less than that required in the black car. Assuming that potential reductions in AC capacity and engine ancillary load scale linearly with increase in shell solar reflectance, ADVISOR simulations of the SC03 driving cycle indicate that substituting a typical cool-coloured shell ($\rho = 0.35$) for a black shell ($\rho = 0.05$) would reduce fuel consumption by 0.12 L per 100 km (1.1%), increasing fuel economy by 0.10 km L^{-1} [0.24 mpg] (1.1%). It would also decrease carbon dioxide (CO_2) emissions by 2.7 g km^{-1} (1.1%), nitrogen oxide (NO_x) emissions by 5.4 mg km^{-1} (0.44%), carbon monoxide (CO) emissions by 17 mg km^{-1} (0.43%), and hydrocarbon (HC) emissions by 4.1 mg km^{-1} (0.37%). Selecting a typical white or silver shell ($\rho = 0.60$) instead of a black shell would lower fuel consumption by 0.21 L per 100 km (1.9%), raising fuel economy by 0.19 km L^{-1} [0.44 mpg] (2.0%). It would also decrease CO_2 emissions by 4.9 g km^{-1} (1.9%), NO_x emissions by 9.9 mg km^{-1} (0.80%), CO emissions by 31 mg km^{-1} (0.79%), and HC emissions by 7.4 mg km^{-1} (0.67%). The simulations may underestimate emission reductions because emissions in standardized driving cycles are typically lower than those in real-world driving.

12/01354 Preparation and properties of gypsum-based heat storage and preservation material

Li, M. *et al. Energy and Buildings*, 2011, 43, (9), 2314–2319.

The paraffin/expanded perlite shape-stabilized phase change material (PCM) was prepared by absorbing paraffin into pores of expanded perlite with vacuum adsorption method (VA method). The gypsum-based heat storage and preservation material was prepared by mixing the prepared paraffin/expanded perlite shape-stabilized PCM and gypsum. Scanning electron microscopy (SEM) was used to investigate the influence of the VA method and free adsorption method (FA method) on the microstructure of the paraffin/expanded perlite PCM. Differential scanning calorimetry (DSC) and exudation experiment were used to test the thermal property and shape-stability of the paraffin/expanded perlite PCM, respectively. The thermal conductivity, bending strength and compressive strength were also tested. The results showed that paraffin was uniformly distributed in pores of expanded perlite in the paraffin/expanded perlite PCM prepared with the VA method. The paraffin/expanded perlite PCM had satisfied shape-stability. The thermal conductivity of gypsum was decreased by addition of the paraffin/expanded perlite PCM. The adsorption amount of paraffin had little effect on the bending strength and compressive strength of the gypsum-based heat storage and preservation material.

12/01355 Pressure drop and mixing in single phase microreactors: simplified designs of micromixers

Holvey, C. P. *et al. Chemical Engineering and Processing: Process Intensification*, 2011, 50, (10), 1069–1075.

Continuous flow microreactors can greatly improve the safety and product yields of processes in the pharmaceutical and fine chemical industry by overcoming many of the drawbacks of traditional batch and semi-batch stirred reactors. This study compares on a common scale the pressure drop and mixing performance of different size commercial microreactor plates composed of a tangential, SZ-shaped or caterpillar mixer followed by a rectangular serpentine main channel. The pressure drop was fitted to a friction factor model, which suggests that the mixing zone had significant chaotic secondary flow patterns, whereas the main channel did not. Moreover, the mixing zone was the main contributor to the overall pressure drop. Mixing performance was then characterized using competitive parallel reactions. Upon the formation of chaotic secondary flows, typically due to the interactions of artificially induced vortices, the mixer performance was found to be independent of geometry for a given energy dissipation rate. However, the mixer geometry will affect the critical Reynolds number that induces chaotic advection and changes the mixing time scale.

12/01356 Primary energy savings through thermal storage in district heating networks

Verda, V. and Colella, F. *Energy*, 2011, 36, (7), 4278–4286.

District heating is an efficient way to provide heat to residential, tertiary and industrial users. Heat is often produced by CHP (combined heat and power) plants, usually designed to provide the base thermal load (40–50% of the maximum load) while the rest is provided by boilers. The use of storage tanks would permit to increase the annual operating hours of CHP: heat can be produced when the request is low (for instance during the night), stored and then used when the request is high. The use of boilers results partially reduced and the thermal load diagram is flattered. Depending on the type of CHP plant this may also affect the electricity generation. All these considerations are crucial in the free electricity market. In this paper, a multi-scale model of storage tanks is proposed. This model is particularly suitable to analyse the operation of storage systems during the heating season and to predict their effects on the primary energy consumption and cash flows. The analysis is conducted considering the Turin district heating system as case study. Results show that primary energy consumption can be reduced up to 12%, while total costs can be reduced up to about 5%.

12/01357 Scale-up concept for modular microstructured reactors based on mixing, heat transfer, and reactor safety

Kockmann, N. and Roberge, D. M. *Chemical Engineering and Processing: Process Intensification*, 2011, 50, (10), 1017–1026.

Microstructured reactors are characterized by rapid mixing processes and excellent temperature control of chemical reactions. These properties allow the safe operation of hazardous chemistry in intensified processes. Problems occur during scale-up of these processes, where heat transfer becomes the limiting effect. With high flow rates and transitional or even turbulent flow regimes in small channels, rapid mixing and excellent heat transfer can be maintained up to high production rates. For exothermic reactions, limits for parametric sensitivity and safe operation are shown from literature and combined with convective heat transfer for consistent scale-up. Good knowledge of reaction kinetics, thermodynamics and heat transfer is essential to determine runaway regions for exothermic reactions. From these correlations, consistent channel design and continuous-flow reactor setup is shown.

12/01358 Stearic acid/silica fume composite as form-stable phase change material for thermal energy storage

Wang, Y. *et al. Energy and Buildings*, 2011, 43, (9), 2365–2370.

The aim of this research is to prepare a novel form-stable composite phase change material (PCM) for the latent heat thermal energy storage (LHTES) in buildings, passive solar space heating by impregnating of stearic acid (SA) into silica fume (SF) matrix through the technique of solution impregnation. The structure, thermal properties, thermal reliability, thermal conductivity and heat storage or release performance of the composite PCM were determined by scanning electron microscope (SEM), Fourier transformation infrared (FTIR), differential scanning calorimetry (DSC) and thermal cycling test analysis technique. The results show that the form-stable composite PCM has the optimal effect, preventing the leakage of SA from the composite, emerges when the SA and SF mass ratio is 1:0.9. The SA loaded on the matrix surface by physical attraction with the mass ratio of 47% during the preparation process. The latent heat of the composite PCM is measured as 82.53 J/g for the melting process and 84.47 J/g for the freezing process, respectively, which indicate the heat storage ability of composite is connected with the mass ratio of SA in composite. The results of DSC, FTIR and thermal cycling test are all show that the thermal reliability of the composite PCM has an imperceptible change. The increase of thermal conductivity was also confirmed by comparing the melting time, freezing time and phase change time of the composite with that of SA. All of the conclusions indicate that the composite has a better thermal conductivity and good thermal and chemical stability.

12/01359 The influence of environmental and geometrical factors on air-ground tube heat exchanger energy efficiency

Trzaski, A. and Zawada, B. *Building and Environment*, 2011, 46, (7), 1436–1444.

More and more efficient solutions of thermal insulation of buildings result in an increasing role of ventilation in the energy balance of buildings. This leads to a necessity for seeking unconventional heat sources, as well as development of the exhaust air heat recovery methods. The use of heat accumulating potential of the ground perfectly fits into this trend, allowing natural pre-heating and pre-cooling of the inlet air. There appears to be very limited research and published data on their thermal performance in Poland. This paper introduces a developed method of air-ground heat exchanger (AGHX) performance evaluation together with its validation and research results of conducted simulation. The AGHX model (based on a quasi 3D finite elements method) allows analysis of energy performance dependence on a wide range of parameters including AGHX geometrical configuration, mode of operation and environmental factors. The simulation results indicate that the analysed parameters in various degrees affect the thermal efficiency of AGHX; various is also the nature of their impact. For some of them it is possible to set a value to maximize heat or cold yield (pipe diameter and placement depth, number of parallel pipes, bypass system, soil thermophysical parameters, ground area shading and ground surface cover). In other cases, the influence of parameters has an asymptotic nature for which the maximum heating or cooling efficiency is achieved for parameter values tending to infinity (pipe length and distance between parallel pipes).

12/01360 The thermal mechanism of warm in winter and cool in summer in China traditional vernacular dwellings

Liu, J. *et al. Building and Environment*, 2011, 46, (8), 1709–1715.

Yaodong is one representative of western China vernacular dwellings. Its indoor thermal environment is cool in summer and warm in winter. This study interprets the characteristic of warm in winter and cool in summer in such a dwelling by measuring the indoor, outdoor and wall's temperatures in winter and summer. The human thermal comfort theory is used to evaluate thermal environment, and the periodic heat transfer mechanism is used to analyse the thermal transfer through the wall. The results show that the Yaodong thick wall effectively damping external temperature wave and keeping steady inner surface temperature are the chief causes of warm in winter and cool in summer in Yaodong, which lays a scientific basis for low energy building design.

12/01361 Thermal performance and optimum insulation thickness of building walls with different structure materials

Ozel, M. *Applied Thermal Engineering*, 2011, 31, (17–18), 3854–3863.

This study deals with thermal performance and optimum insulation thickness of building walls with different structure materials under dynamic thermal conditions. Thermal performance of building walls constructed of concrete, briquette, brick, blokbims and autoclaved aerated concrete (AAC) is determined for uninsulated and insulated wall structures. Extruded polystyrene (XPS) and expanded polystyrene (EPS) as insulation material are selected. The yearly cooling and heating transmission loads are calculated by using an implicit finite difference method under steady periodic conditions. These loads are used as inputs to an economic model including the cost of insulation material and the present value of energy consumption cost over lifetime of 10 years of the building to determine the optimum insulation thickness. The investigation is carried out for a south-facing wall and the climatic conditions of Elaziğ, Turkey. Results show that the optimum insulation thicknesses vary between 2 and 8.2 cm, the energy savings vary between 2.78 and 102.16 $/m^2, and the payback periods vary between 1.32 and 10.33 years depending on five different structure materials and two different insulation materials. Results are compared with the degree-days method.

12/01362 Thermosyphon heat-pipe evacuated tube solar water heaters for northern maritime climates

Redpath, D. A. G. *Solar Energy*, 2012, 86, (2), 705–715.

Under transient climatic conditions previous research has reported that evacuated tube solar water heaters (ETSWHs) with heat-pipe absorbers are the most effective solution for collection of solar energy. The cost of such systems is greater than the mass produced 'water in glass' evacuated tube solar water heater mainly manufactured in China. Previous studies have reported that the costs of solar water heating can be reduced through the adoption of thermosyphon fluid circulation. Well-designed thermosyphon systems are as effective as pumped systems but with lower capital and running costs. To investigate if costs could be reduced and performance levels maintained, outdoor testing of three thermosyphon heat-pipe ETSWHs primarily designed for pumped fluid circulation was carried out under a northern maritime climate. Experimental data from a year's side by side monitoring of two thermosyphon ETSWHs (both with the same area of 2 m^2) was collected and used to validate a correlation based on a modified version of the *f*-chart design tool between the observed and expected performance for both systems. The R^2 value between measured and predicted monthly solar fractions was greater than 0.99 for both systems. The R^2 value between measured and predicted diurnal solar fractions was calculated as greater than 0.95 for both systems. The only difference between the two was that one utilized internal heat-pipe condensers whilst the other used external ones. The system with internal condensers was found to be 17% more efficient. A simplifying assumption of a constant temperature rise across the collectors reduced the calculations required to predict the performance of thermosyphon heat-pipe ETSWHs and was also statistically significant. To determine if the assumption was valid for other thermosyphon heat-pipe ETSWHs with different collector parameters a third system with internal condensers an area of 3 m^2, a heat removal factor (F_R) of 0.816 based on the absorber area and a collector loss coefficient ($F_R U_L$) of 2.25 W m^{-2} K^{-1} was assembled and its performance monitored, when the same assumption was applied the R^2 value between the measured and predicted daily solar fractions was calculated as 0.96 experimentally demonstrating that this relationship was still statistically significant for another heat-pipe thermosyphon ETSWH with different collector parameters.

12/01363 Using advanced cool materials in the urban built environment to mitigate heat islands and improve thermal comfort conditions

Santamouris, M. *et al. Solar Energy*, 2011, 85, (12), 3085–3102.
The paper considers cool materials (i.e. materials with high solar reflectance and infrared emittance) for buildings and urban structures. The research in this field is roughly divided in four phases and includes the development and assessment of: (a) highly reflective and emissive light-coloured materials, (b) cool-coloured materials, i.e. coloured materials with increased near infrared and thus overall solar reflectance compared to similarly coloured conventional ones, (c) phase change materials and (d) dynamic cool materials. All major aspects related to each technology are described and the benefits and impacts of these materials at building, city and global scale are reported. The wide use of such materials can significantly contribute to the mitigation of the heat island effect and the improvement of urban environmental quality.

12/01364 Validation of a mathematical model for encapsulated phase change material flat slabs for cooling applications

Liu, M. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2340–2347.
A one-dimensional liquid-based model for a flat slab phase change thermal storage unit was developed. The model allows for varying wall temperatures along the direction of flow and integrates a convective boundary layer using a previously developed algorithm, which is employed to iteratively calculate the liquid fraction and the temperature of each phase change material (PCM) node. The melting and freezing processes are analysed based on the temperatures of the heat transfer fluid nodes, the wall nodes and the PCM nodes during melting and freezing. The mathematical model developed was validated using two sets of experimental data obtained from tests using a PCM having a melting point of −26.7 °C and a liquid glycol based heat transfer fluid. The numerical results show a good agreement with the experimental ones.

12/01365 Woven graphite fiber structures for use in ultra-light weight heat exchangers

Hemrick, J. G. *et al. Carbon*, 2011, 49, (14), 4820–4829.
Lightweight, robust woven graphite-fibre structures were developed for heat exchangers which provide high conductivity paths along the direction of the graphite fibres. These structures were produced and characterized for air permeability/pressure drop and thermal (heat transfer) performance. Results indicate that the materials are suitable for use in ultra-light weight heat exchanger applications such as vehicle radiators or other areas where light weight, compact, conformable heat transfer devices are needed.

11 ENGINES

Power generation and propulsion, electrical vehicles

12/01366 Adaptive neuro-fuzzy inference system to improve the power quality of a split shaft microturbine power generation system

Oğuz, Y. *et al. Journal of Power Sources*, 2012, 197, 196–209.
This article presents design of adaptive neuro-fuzzy inference system (ANFIS) for the turbine speed control for purpose of improving the power quality of the power production system of a split shaft microturbine. To improve the operation performance of the microturbine power generation system (MTPGS) and to obtain the electrical output magnitudes in desired quality and value (terminal voltage, operation frequency, power drawn by consumer and production power), a controller depended on adaptive neuro-fuzzy inference system was designed. The MTPGS consists of the microturbine speed controller, a split shaft microturbine, cylindrical pole synchronous generator, excitation circuit and voltage regulator. Modelling of dynamic behaviour of synchronous generator driver with a turbine and split shaft turbine was realized by using the Matlab/Simulink and SimPowerSystems in it. It is observed from the simulation results that with the microturbine speed control made with ANFIS, when the MTPGS is operated under various loading situations, the terminal voltage and frequency values of the system can be settled in desired operation values in a very short time without significant oscillation and electrical production power in desired quality can be obtained.

12/01367 Catalytic performance of supported precious metal catalysts for the combustion of diesel particulate matter

Lim, C.-B. *et al. Catalysis Today*, 2011, 175, (1), 106–111.
CeO_2 and TiO_2 supported precious metal (Ag, Pt and Pd) catalysts were prepared by an impregnation method, and their catalytic performance for oxidation of simulated diesel particulate matter (PM) was investigated by thermogravimetry (TG), differential thermal analysis (DTA) and mass spectrometry (MS) under both tight-contact (TC) and loose-contact (LC) conditions. The simulated PM was prepared by liquid-phase adsorption of SOF (eicosane, $C_{20}H_{42}$) on soot (carbon black). Catalytic performance for the oxidation of simulated PM depended on both metal species and supports. CeO_2 was inherently active for both SOF and soot oxidation, and TiO_2 was nearly inactive. Pt was the most active species for SOF oxidation, followed by Pd and Ag. The SOF oxidation was independent of contact condition between the simulated PM and catalysts. Soot oxidation performance, on the other hand, drastically affected by the contact conditions, and Ag was far more active than Pt and Pd under both TC and LC conditions. Ag/CeO_2 was the most active soot oxidation catalyst. The oxidation of soot was influenced by the coexisting SOF depending on catalytic materials and contact modes.

12/01368 Effect of exhaust gas recirculation on the cycle-to-cycle variations in a natural gas spark ignition engine

Sen, A. K. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2247–2253.
This study investigates the effect of exhaust gas recirculation (EGR) on the cycle-to-cycle variations (CCV) in combustion in a natural gas spark ignition engine. The engine is operated at 2000 rpm and a stoichiometric fuel-air mixture is used. The EGR level is changed from 0% to 5%, 10%, 15%, and 20%. For each EGR level, a continuous wavelet transform is used to analyse the time series of the indicated mean effective pressure (IMEP) over 200 cycles. The dominant oscillatory modes of the CCV are identified and the engine cycles over which these modes may persist are delineated. The results reveal that the CCV of the IMEP occur on multiple timescales and exhibit complex dynamics. With no EGR, mainly high frequency intermittent fluctuations are observed. As the EGR level is increased, more persistent low frequency variations tend to develop. In addition, the spectral power increased with an increase in the EGR level. At the EGR level of 20%, the spectral power is found to increase significantly indicating that EGR has a pronounced effect on increasing the CCV. Knowledge of the dominant modes of variability may be useful to develop effective control strategies for reducing the CCV and improving engine performance in the presence of EGR.

12/01369 In situ observation of platinum sintering on ceria-based oxide for autoexhaust catalysts using Turbo-XAS

Nagai, Y. *et al. Catalysis Today*, 2011, 175, (1), 133–140.
Using a time resolved X-ray absorption spectroscopy (XAS) technique, the authors studied an *in situ* dynamic observation of sintering for Pt particles supported on a ceria-based oxide and Al_2O_3 supports under cyclic oxidizing/reducing conditions at 800 °C. The effect of the support oxide and the amount of Pt loading on the Pt sintering was investigated. The sintering of Pt particles in 2 wt% Pt/ceria-based oxide could be inhibited, when compared to in 2 wt% Pt/Al_2O_3. Moreover, 0.5 wt% Pt and 1 wt% Pt/ceria-based oxide with a lower Pt loading brought higher stability of Pt against sintering. For a 0.5 wt% Pt/ceria-based oxide catalyst, sintering was completely inhibited and highly dispersed Pt particles (particle size; 1.5 nm) were maintained under redox cycling at 800 °C. These results lead to the conclusion that Pt–O–Ce bond formation on the surface of a ceria-based oxide under oxidative conditions in redox cycling inhibits the sintering of Pt particles, and that the Pt–O–Ce anchor site (its strength and number) has an important role in the sintering inhibition of Pt particles on ceria-based oxide. In addition, the apparent change in the oxygen storage/release performance of ceria-based oxide from the viewpoint of the Pt particle size and the intrinsic bulk behaviour of ceria-based oxide is noted and discussed.

12/01370 Molten carbonate fuel cell and gas turbine hybrid systems as distributed energy resources

Wee, J.-H. *Applied Energy*, 2011, 88, (12), 4252–4263.
Molten carbonate fuel cell (MCFC)/gas turbine (GT) hybrid system has attracted a great deal of research effort due to its higher electricity efficiency. However, its technology has remained at the conceptual

level due to incomplete examination of the related issues, challenges and variables. To contribute to the development of system technology, the MCFC/GT hybrid system is analysed and discussed herein. A qualitative comparison of the two kinds of MCFC/GT hybrid system, indirect and direct, is hindered by the many variables involved. However, the indirect system may be preferred for relatively small-scale systems with the micro-GT. The direct system can be more competitive in terms of system efficiency and GT selection due to the optionality of system layouts as well as even higher GT inlet temperature. System layout is an important factor influencing the system efficiency. The other issues such as GT selection, system pressurization and part-load operation are also significant.

12/01371 Robust controller design of heat pump and plug-in hybrid electric vehicle for frequency control in a smart microgrid based on specified-structure mixed H_2/H_∞ control technique

Vachirasricirikul, S. and Ngamroo, I. *Applied Energy*, 2011, 88, (11), 3860–3868.

This paper proposes a new robust controller design of heat pump (HP) and plug-in hybrid electric vehicle (PHEV) for frequency control in a smart microgrid (MG) system with wind farm. The intermittent power generation from wind farm causes severe frequency fluctuation in the MG. To alleviate frequency fluctuation, the smart control of power consumption of HP and the power charging of PHEV in the customer side can be performed. The controller structure of HP and PHEV is a proportional integral derivative (PID) with single input. To enhance the performance and robustness against system uncertainties of the designed controller, the particle swarm optimization based-mixed H_2/H_∞ control is applied to design the PID controllers of HP and PHEV. Simulation studies confirm the superior robustness and frequency control effect of the proposed HP and PHEV controllers in comparison to the conventional controller.

12/01372 The deconvolution of the thermal, dilution, and chemical effects of exhaust gas recirculation (EGR) on the reactivity of engine and flame soot

Al-Qurashi, K. *et al. Combustion and Flame*, 2011, 158, (9), 1696–1704.

In a recent paper, the authors demonstrated that the exhaust gas recirculation (EGR) enhanced the oxidative reactivity of diesel engine soot. In this paper, they show that simulated EGR, via carbon dioxide (CO_2) addition to the intake air to an engine at concentrations of 0, 2, 4, and 8 vol.% and to the oxidizer stream of an ethylene diffusion flame at concentrations of 0, 5, and 10 vol.%, affects the reactivity of the soot in the same manner as actual EGR. Motivated by this fact, post-flame ethylene soot was produced from a co-flow laminar diffusion flame to better understand the mechanism by which the CO_2 affects soot reactivity. This objective was accomplished by successfully isolating and examining the thermal, dilution, and chemical effects of the CO_2 on soot reactivity. These three effects account for 45%, 35%, and 20% of the total reactivity of soot respectively, with the thermal effect being the most important factor governing the soot reactivity. The results showed that all of these effects account for a measurable increase in soot reactivity.

Hybrid engine systems

12/01373 Analysis of unregulated emissions from an off-road diesel engine during realistic work operations

Lindgren, M. *et al. Atmospheric Environment*, 2011, 45, (30), 5394–5398.

Emissions from vehicle diesel engines constitute a considerable share of anthropogenic emissions of pollutants, including many non-regulated compounds such as aromatic hydrocarbons and alkenes. One way to reduce these emissions might be to use fuels with low concentrations of aromatic hydrocarbons, such as Fischer–Tropsch (F–T) diesels. Therefore this study compared Swedish environmental class 1 diesel (EC1) with the F–T diesel fuel Ecopar^{TM} in terms of emissions under varied conditions (steady state, controlled transients and realistic work operations) in order to identify factors influencing emissions in actual operation. Using F–T diesel reduced emissions of aromatic hydrocarbons, but not alkenes. Emissions were equally dependent on work operation character (load, engine speed, occurrence of transients) for both fuels. There were indications that the emissions originated from unburned fuel, rather than from combustion products.

12/01374 Chemical analysis and ozone formation potential of exhaust from dual-fuel (liquefied petroleum gas/gasoline) light duty vehicles

Adam, T. W. *et al. Atmospheric Environment*, 2011, 45, (17), 2842–2848.

Measures must be undertaken to lower the transport sector's contribution to anthropogenic emissions. Vehicles powered by liquefied petroleum gas (LPG) are an option due to their reduced emissions of air pollutants compared to engines with conventional fuels. In the present study, 10 different dual-fuel LPG/gasoline light-duty vehicles were tested, which all complied with European emission level legislation EURO-4. Tests with LPG and gasoline were performed on a chassis dynamometer by applying the new European driving cycle (NEDC) and emission factors and ozone formation potentials of both kinds of fuels were compared. The components investigated comprised regulated compounds, CO_2, volatile hydrocarbons and carbonyls. On-line analysis of aromatic species was carried out by resonance-enhanced multiphoton ionization–time-of-flight mass spectrometry (REMPI–TOFMS). It is demonstrated that utilization of LPG can entail some environmental benefits by reducing emissions. However, for dual-fuel LPG/gasoline vehicles running on LPG the benefits are less than expected. The main reason is that dual-fuel vehicles usually start the engine up on gasoline even when LPG is selected as fuel. This cold-start phase is crucial for the quality of the emissions. Moreover, an influence on the chemical composition of emissions of vehicle performance, fuel and the evaporative emission system of the vehicles is demonstrated.

12/01375 Combustion characteristics and engine emissions of a diesel engine fueled with diesel and treated waste cooking oil blends

Abu-Jrai, A. *et al. Chemical Engineering Journal*, 2011, 172, (1), 129–136.

In this study, waste cooking oil from restaurants was used to produce a renewable and sustainable biodiesel through transesterification process. The treated waste cooking oil (TWCO) fuel produced has shown very promising chemical and physical properties; most notably; cetane number (~49) and sulfur content (8 mg/kg). The combustion of conventional diesel and TWCO–diesel blend (50/50 by volume; shown as TD50) was examined at different engine conditions. The combustion of TD50 resulted in a considerable reduction in the smoke opacity and unburned hydrocarbons associated with an increase in the CO_2 and NO_x emissions due to unintentional advance of fuel injection timing, caused by the higher bulk modulus of TD50 fuel. Results indicated an increase in brake specific fuel consumption with simultaneous reduction in the engine thermal efficiency compared to conventional diesel. The lower smoke opacity in the case of TD50 fuel assists NO_x reductions by exploiting the higher EGR tolerance of TD50 fuel. Thus, a more encouraging NO_x-smoke tradeoff may be selected to reduce both NO_x and smoke. The effect of EGR in NO_x reduction was more noticeable with TD50 than conventional diesel fuel.

12/01376 Estimation of double-Wiebe function parameters using least square method for burn durations of ethanol-gasoline blends in spark ignition engine over variable compression ratios and EGR levels

Yeliana, Y. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2213–2220.

Phasing and duration are two of the most important aspects of combustion in spark ignition (SI) engines. They impact efficiency, emissions, and overall engine performance. These aspects of combustion can be represented by the mass fraction burn (MFB) profile. Having an accurate mathematical model of the MFB profile leads to an ability to model the combustion process and, thus, properly model the overall engine in 1D engine simulation tools. The Wiebe function is widely used in engine simulation to estimate the MFB profile as a function of crankshaft position. In this work, for the purpose of validating a sub-process, the Wiebe function parameters were calculated using an analytical solution and a least squares method by fitting MFB locations, as determined from analysis of measured cylinder pressure, to both single and double-Wiebe functions. To determine the accuracy of the respective Wiebe function, a single-zone pressure model was applied to reconstruct the pressure trace. Once the pressure trace is recovered, the reconstructed pressure trace is then compared with the experimentally measured cylinder pressure trace. Results showed that the double-Wiebe function model fit better than the single-Wiebe function model. The root mean square error (RMSE) of the reconstructed pressure trace using the double-Wiebe estimation is 7.9 kPa. In comparison, the RMSEs of the reconstructed pressure traces using the single-Wiebe analytical solution and single-Wiebe least squares methods were 70.0 kPa and 75.9 kPa, respectively, demonstrating a significant improvement.

12/01377 Performance and emissions of a diesel tractor engine fueled with marine diesel and soybean methyl ester

Gokalp, B. *et al. Biomass and Bioenergy*, 2011, 35, (8), 3575–3583.

Biodiesel is an alternative fuel that is cleaner than petrodiesel. Biodiesel can be used directly as fuel for a diesel engine without having to modify the engine system. It has the major advantages of having high biodegradability, excellent lubricity and no sulfur content.

This paper presents the results of investigations carried out in studying the fuel properties of soybean methyl ester (SME) and its blend with marine diesel fuel from 5%, 20% and 50% blends by volume and in running a diesel engine with these fuels. The results indicate that the use of biodiesel produces lower smoke opacity (up to 74%), but higher brake specific fuel consumption (BSFC) (up to 12%) compared to marine fuel (MF). The measured carbon monoxide (CO) emissions of B5 and B100 fuels were found to be 3% and 52% lower than that of the MF, respectively.

12/01378 Theoretical and experimental investigation of diesel engine performance, combustion and emissions analysis fuelled with the blends of ethanol, diesel and jatropha methyl ester

Kannan, D. *et al. Energy Conversion and Management*, 2012, 53, (1), 322–331.

In this work addition of ethanol to high viscosity jatropha methyl ester (JME) through port injection is investigated in order to determine its effect fuel viscosity reduction on diesel engine performance. In addition to viscosity alteration, the impact of ethanol addition on combustion characteristics such as combustion duration, ignition delay and emissions levels from diesel engines fuelled with blends of ethanol, diesel and JME is studied in particular. It is found that blending of oxygenated fuels with diesel modifies the chemical structure and physical properties which again alter the engine operating conditions, combustion parameters and emissions levels. However, the injection of only 5% ethanol through port injection allows for a total of 25% blending of biofuels into diesel yet keeping the fuel characteristics close to that of conventional diesel. However, both experimental and numerical results show that ethanol addition in JME blended diesel results in a slight increase in fuel consumption and thermal efficiency for the same power outputs as that of conventional diesel fuel. Also, the combustion characteristics with ethanol addition include improved maximum in-cylinder peak pressure, cumulative heat release (CHR) rate of heat release (ROHR), in-cylinder peak temperature and combustion duration. Regarding emission characteristics the experimental results show significant reduction in smoke, carbon monoxide (CO) and total hydrocarbon (THC) emissions with extended oxygen mass percentage in the fuel at higher engine loads. However, oxides of nitrogen (NO_x) emissions are found to increase at high loads although the common tradeoff between smoke and NO_x is found to be more prominent for the oxygenated fuels.

Transport battery development

12/01379 Effects of current collectors on power performance of $Li_4Ti_5O_{12}$ anode for Li-ion battery

Wu, H.-C. *et al. Journal of Power Sources*, 2012, 197, 301–304.

The effects of current collector on the charge/discharge capacity and cycle stability of $Li_4Ti_5O_{12}$ (LTO) electrode under high C-rates (up to 20 C) have been investigated by applying five types of current collectors, including a Al foil, an anodization-etched Al (E-Al), the same etched Al with a conformal C coating (C-E-Al), a Cu foil (Cu) and the same Cu foil with a C coating (C-Cu). The C coatings on both metal current collectors are deposited by a chemical vapour deposition process using CH_4 at 600 °C. The capacities of the LTO electrodes above 1 C rate are in the order of Al < E-Al < Cu ~ C-E-Al < C-Cu, exhibiting remarkable enhancement in rate performance by the C-coating for both metals. Surface analyses indicate that the enhancement can be attributed to the combination of two factors, including removal of the native oxide layer and modification of surface hydrophobicity, which improves adhesion of active layer, on the current collector surface. Both contribute to the reduction of the resistance at the current-collector/active layer interface. All electrodes show good cycle stability.

12/01380 Infantry mobility hybrid electric vehicle performance analysis and design

Jimenez-Espadafor, F. J. *et al. Applied Energy*, 2011, 88, (8), 2641–2652.

Optimal energy flux analysis and design of a power plant for infantry mobility hybrid diesel–electric vehicle is dealt with in this paper. Control strategy management and propulsion system sizing is done on the basis of minimizing total fuel consumption. A quasi-static system model has allowed analysing the most restrictive operations; moreover the simulation has been used in expected real driving cycles in order to check the performance in typical mission. From the point of view of energy consumption and CO_2 emissions, HEV and automatic gear transmission configuration have been compared. The results show a noticeable difference especially in the case of the driving cycle of low-power load conditions, with a very reduced proportion of batteries weight in comparison to vehicle. Fuel and emissions saving with HEV systems compared to automatic geared transmission along vehicle service life justify the higher inversion needed for the HEV system.

12/01381 Kalman filtering state of charge estimation for battery management system based on a stochastic fuzzy neural network battery model

Xu, L. *et al. Energy Conversion and Management*, 2012, 53, (1), 33–39.

Extended Kalman filtering is an intelligent and optimal means for estimating the state of a dynamic system. In order to use extended Kalman filtering to estimate the state of charge (SOC), a mathematical model that can accurately capture the dynamics of battery pack is needed. In this paper, the authors propose a stochastic fuzzy neural network (SFNN) instead of the traditional neural network that has filtering effect on noisy input to model the battery non-linear dynamic. Then, the paper studies the extended Kalman filtering SOC estimation method based on a SFNN model. The modelling test is realized on an 80 Ah Ni/MH battery pack and the federal urban driving schedule (FUDS) cycle is used to verify the SOC estimation method. The maximum SOC estimation error is 0.6% compared with the real SOC obtained from the discharging test.

12/01382 Three dimensional solid-state supercapacitors from aligned single-walled carbon nanotube array templates

Pint, C. L. *et al. Carbon*, 2011, 49, (14), 4890–4897.

This study demonstrates the fabrication of solid-state dielectric energy storage materials from self-assembled, aligned single-walled carbon nanotube arrays (VA-SWNTs). The arrays are transferred as intact structures to a conductive substrate and the nanotubes are conformally coated with a thin metal-oxide dielectric and a conductive counter-electrode layer using atomic layer deposition. Experimental results yield values in agreement with those obtained through capacitive modelling using Al_2O_3 dielectric coatings ($C > 20\,mF/cm^3$), and the solid-state dielectric architecture enables the operation of these devices at substantially higher frequencies than conventional electrolyte-based capacitor designs. Furthermore, modelling of supercapacitor architectures utilizing other dielectric layers suggests the ability to achieve energy densities above 10 W h/kg while still exhibiting power densities comparable to conventional solid-state capacitor devices. This device design efficiently converts the high surface area available in the conductive VA-SWNT electrode to space for energy storage while boasting a robust solid-state material framework that is versatile for use in a range of conditions not practical with current energy storage technology.

12 REFRACTORIES/ CERAMICS

Properties, production, applications

12/01383 Acidic dissolution behavior of U containing ZrO_2–MgO ceramics

Holliday, K. *et al. Annals of Nuclear Energy*, 2011, 38, (11), 2404–2409.

This study explores the possibility of dissolving zirconia–magnesia inert matrix fuel containing uranium oxide as a fissile material and plutonium homolog and erbium oxide as a burnable poison with nitric and sulfuric acid as a potential first step in a reprocessing scheme. The progress of the dissolution is followed by monitoring the amount of material in solution by inductively coupled plasma-atomic emission spectroscopy, assessing the speciation of the material by time resolved laser fluorescence spectroscopy, and determining and quantifying the crystalline phases present in the remaining residue by X-ray diffraction. This study has shown a linear incongruent dissolution of the cubic zirconia phase in concentrated nitric acid under certain chemical compositions, while the magnesium oxide phase is completely soluble. In sulfuric acid uranium, erbium, and magnesium are soluble to different extents while zirconium forms a colloidal suspension that conglomerates and settles out of solution. The feasibility of the dissolution of zirconia–magnesia inert matrix fuel with nitric and sulfuric acid for reprocessing is discussed.

12/01384 Calculation of the glass cover temperature and the top heat loss coefficient for 60° vee corrugated solar collectors with single glazing

Mahboub, C. and Moummi, N. *Solar Energy*, 2012, 86, (2), 804–808.

In this paper, the top heat losses from a 60° vee corrugated solar collector with single glazing have been investigated. An approximate method for computation of glass cover temperature and top heat loss coefficient has been followed. A modified equation from Akhtar and Mullick's relation was proposed. The predicted values of the glass cover temperature and the top heat loss coefficient were compared with the results obtained by iterative solution of the energy balance equations over a wide range of operating conditions. A good accuracy is provided by the proposed equation which is recommended to be used in the energy analysis of the present configuration.

12/01385 Capacitive effect on the heat transfer through building glazing systems

Freire, R. Z. *et al. Applied Energy*, 2011, 88, (12), 4310–4319.

In recent years, several intensive studies have been carried out in order to reduce the energy consumption of buildings. One solution lies on whole building energy simulation that permits to enable the heat (and moisture) transfer through the building envelope and, consequently, is a way to understand how to improve the building performance. This article aims to analyse the modelling level needed to successfully evaluate the heat transfer through glazing parts of windows in such whole-building simulations as it is well-known that windows are the thermally weakest elements of the building envelope. In this way, predictions of glazing surface and zone air temperatures and energy demand obtained using both resistive and finite-volume based models are compared. Results show that for common window glazing structure and outdoor/indoor perturbations, differences between the two models are small. However, in the case of glazing presenting higher solar absorption and thermal inertia, the use of the finite-volume based model is required to accurately predict the glazing internal surface temperature and avoid errors up to 50% for energy consumption in the studied case. Those results put into relief a clear limitation of current whole energy simulation programs to correctly predict the energy consumption of buildings where high thermal inertia double- or triple-glazing windows are installed.

12/01386 CFD assessment of the performance of lateral ventilation in double glazed façades in Mediterranean climates

Guardo, A. *et al. Energy and Buildings*, 2011, 43, (9), 2539–2547.

Implementation of double-glazed façades (DGF) in buildings has been an object of broad study and application in recent years, both in new and existing constructions. However, there is little experience in predicting the operating behaviour of a DGF. Sometimes the results obtained are not satisfactory and an extra energetic cost is necessary to obtain suitable comfort conditions in the inner space of the building, especially in Mediterranean climates, where large solar gains are a constant condition along throughout the year, and such large semi-transparent areas can produce significant over-heating in buildings. Computational fluid dynamics (CFD) has proven to be a useful tool for modelling air flow and heat transfer in DGF including conduction, convection and radiation heat transfer phenomena. The aim of this work was to evaluate, by means of CFD, the influence of several lateral ventilation systems including the variation of the flow inlet (e.g. uniform or swirl flow inlet) and analysing different inlet flow configurations (e.g. uniform, inclined, upper or lower crossed inlet flow). From these CFD simulations, a comparative efficiency study, in terms of reduction of solar load gains and energetic requirements, was performed comparing the obtained results for horizontal ventilation against vertical ventilation, which was previously studied by this research group. It was found that using horizontal ventilation schemes would reduce the required air volumetric flow rate within the DGF for obtaining similar reductions in solar load gain to those obtained with vertical ventilation, when the construction and operation parameters of the DGF are equal for both cases.

12/01387 Double window system with ventilation slits to prevent window surface condensation in residential buildings

Kim, J. *et al. Energy and Buildings*, 2011, 43, (11), 3120–3130.

Many Korean apartment units use balconies as semi-indoor spaces by installing external windows. These balconies form environmental buffer spaces to improve comfort and reduce cooling and heating costs. However, the balcony spaces of some units have been removed and have been placed in living rooms. The removal of these environmental buffer spaces has caused problems. Significant heat loss through windows is one of the most serious problems; window surface condensation caused by low surface temperatures in the winter makes residents uncomfortable and damages construction materials. Therefore, it is evident that window design requires improvements. This study introduces a double window system with improved thermal performance and ventilation slits to solve the window surface condensation problem in apartment units without balconies. To verify the thermal performance of the proposed system, temperature factors were analysed by field measurements. The condensation frequencies were also evaluated by temperature factors at an indoor temperature of 25 °C and 55% humidity. Ultimately, the double window system was able to reduce condensation frequency greatly. An examination of the air volume by ventilation slit operational mode found that the case with an open outer window bottom vent and an inner window top ventilation slit, discharged the indoor vapour effectively and increased the dew point of the window's surface.

12/01388 Elastic properties investigation of gamma-radiated barium lead borosilicate glass using ultrasonic technique

Laopaiboon, R. *et al. Annals of Nuclear Energy*, 2011, 38, (11), 2333–2337.

The ultrasonic velocities were measured in barium lead borosilicate glass samples of different compositions before and after irradiation with γ-rays. Measurements were carried out at room temperature and 4 MHz frequency using ultrasonic technique. The ultrasonic velocities data of glass samples have been used to find the elastic modulus and micro-hardness. Densities of glass samples were measured by Archimedes's principle using n-hexane as immersion liquid. It was found that ultrasonic velocity, elastic modulus and micro-hardness increase with increasing barium oxide content and increasing γ-radiation dose.

12/01389 Evaluating the adsorptive capacity of montmorillonitic and calcareous clays on the removal of several heavy metals in aqueous systems

Sdiri, A. *et al. Chemical Engineering Journal*, 2011, 172, (1), 37–46.

The present work aimed to achieve mineralogical and spectroscopic characterization of the Late Cretaceous clays of Aleg formation (Coniacian-Lower Campanian system), Tunisia, for the removal of several toxic metals in aqueous systems. The collected clay samples were first characterized by different techniques including X-ray fluorescence (XRF), thermal analysis (TG/TDA), X-ray diffraction (XRD), Fourier transform infrared (FTIR) and scanning electron microscopy (SEM). Results showed that the natural clay samples are mainly composed of silica, alumina, iron, calcium and magnesium oxides. The sorbents are mainly mesoporous materials with modest specific surface area of $<71\,m^2/g$. Then, the possible use of the studied clay samples as adsorbents for the removal of Pb(II), Cd(II), Cu(II) and Zn(II) from aqueous solutions was evaluated. Langmuir, Freundlich and Dubinin–Radushkevich (D–R) isotherm models were used to simulate the equilibrium data. The maximum adsorption capacity varied between 6.78 and 131.58 mg/g, showing much higher removal efficiency than the relevant previous studies. Langmuir isotherms showed the best fitting to the experimental data. Among the studied clay samples, the amount of calcium carbonates was the most influencing parameter for heavy metal removal. The results suggest that the studied clay samples can be effectively used for the treatment of contaminated wastewaters.

12/01390 Experimental study of free convection in a window with a heated between-panes blind

Almeida, F. and Naylor, D. *Energy and Buildings*, 2011, 43, (10), 2647–2655.

An experimental study has been conducted to examine free convection in a window with an enclosed aluminium venetian-type blind. The unique feature of this experiment was that the blind slats were heated electrically to simulate absorbed solar radiation. Convective heat transfer measurements and temperature field visualization were obtained using a Mach–Zehnder laser interferometer. Optical measurements were made for two glazing spacings, two blind slat angles, two blind heat flux levels, and two glazing temperature differences. Both local and average convective heat flux data were obtained in the centre region of the tall air-filled enclosure. At the widest glazing spacing, the temperature field was found to be unsteady. For these cases, the temporal fluctuation of the local convective heat transfer was time-averaged using a high-speed camera. The experimental results have been compared to a simplified method in the literature for predicting the centre-glass heat flux for this configuration.

12/01391 Optimal synthesis of micro/mesoporous beta zeolite from kaolin clay and catalytic performance for hydrodesulfurization of diesel

Duan, A. *et al. Catalysis Today*, 2011, 175, (1), 485–493.

To be used as the unique sources of silica and alumina, kaolin clay was pretreated by different kinds of acids including H_2SO_2, HCl and H_3PO_2. Through evaluating the synthesis factors of the kaolin clay pretreatment and the crystallization of beta zeolite systematically, the optimal conditions were obtained, i.e. using HCl concentrations of 8.2 mol/L to process kaolin clay at 96 °C for 3 h, and the optimal H_2O/SiO_2 of 3–4, TEAOH/SiO_2 ratio of 0.06, Na_2O/SiO_2 ratio of 0.05 for crystallizing at 170 °C more than 16 h. The typical physicochemical properties of samples were characterized by the techniques of XRD, N_2-adsorption and FT-IR. The supported NiMo/Beta-Al_2O_3 series catalysts with different beta contents were prepared and evaluated in a fixed bed microreactor with FCC diesel. HDS results indicated that NiMo/Beta-Al_2O_3 series catalysts exhibited higher HDS activities compared with the conventional NiMo/Al_2O_3 catalysts, and S in the best product obtained over the catalyst with beta content of 32% was 8.4 $\mu g\, g^{-1}$ which met the S regulation of ultra clean diesel in Euro-V specification. Combined with the sulfur distributions by GC–PFPD method, it could be found that the incorporation of acidic zeolite in the support could favour the deep removal of sulfur compounds.

12/01392 Photocatalytic cement-based materials: comparison of nitrogen oxides and toluene removal potentials and evaluation of self-cleaning performance

Chen, J. *et al. Building and Environment*, 2011, 46, (9), 1827–1833.

Using cement-based building materials as a matrix for nano-photocatalysts is an important development for the large scale application of photocatalytic technologies. Air pollution mitigation and self-cleaning surface are two major applications of photocatalytic building materials. In this study, a comparison was made to evaluate the performance of TiO_2 modified concrete surface layers for NO_x and VOC degradation. The self-cleaning performance of TiO_2 modified self-compacting mortars (SCM) developed for decorative applications was also evaluated. The results show that the photocatalytic conversion of toluene by the TiO_2 modified surface layer was not detected, although NO_x could be effectively removed under the same conditions. The presence of toluene did not influence the NO_x removal process. TiO_2 modified SCM were found to be effective in the discoloration of rhodamine B under UV and strong halogen light irradiation. The level of adsorption of the air contaminants onto the active sites of the cement-TiO_2 composite was identified to be the key factor determining the subsequent photocatalytic efficiency.

12/01393 Syngas production from natural gas via catalytic partial oxidation using ceramic monolith catalyst at short contact time and elevated pressure

Kado, S. *et al. Catalysis Today*, 2011, 171, (1), 97–103.

The development of the catalyst suitable for the catalytic partial oxidation (CPOX) of natural gas was investigated for the efficient production of synthesis gas. The catalyst of Rh/$CeO_2 + ZrO_2 +$ MgO was found to show higher catalytic performance than Rh/MgO. The additional effect of CeO_2 and ZrO_2 to Rh/MgO on catalytic property was studied by H_2-TPR, isotopic oxygen exchange reaction and DRIFT spectroscopy. And it was revealed that the state of Rh can maintain metallic phase during the CPOX reaction, and that oxygen can be supplied from lattice oxygen, and that adsorbed CO can desorb easily. The application of foam monolith catalyst coated with developed support materials to high pressure and short contact time CPOX reaction has been investigated, and this study has succeeded in demonstrating the stable catalytic performance for 2000 h at 1.0 MPa and 500,000 h^{-1} GHSV.

12/01394 The glazing temperature measurement in solar stills – errors and implications on performance evaluation

Tsilingiris, P. T. *Applied Energy*, 2011, 88, (12), 4936–4944.

Although the brine temperature measurement in solar stills would be more or less conventional, the precise condensing surface temperature measurement, appears to present a significant difficulty to measure. In the present investigation, an analysis is developed aiming to underline the parameters affecting the glazing surface temperature measurement and a series of field measurements are presented, aiming to identify and evaluate the errors associated to the measurement of this crucial physical quantity. It is derived that among other reasons the surface temperature measurement accuracy may strongly be degraded owing to the sensor tip overheating due to the radiation absorption, as well as to the development of poor bond conductance between sensor bead and glazing surface. It may also be degraded owing to the temperature drop across the glazing thickness and the non-uniform temperature distribution over the entire condensing surface area, something that makes the selection of the appropriate location of the particular temperature transducer necessary. Based on the derived measurements, an order of magnitude analysis is employed for the approximate evaluation of error range in the condensing surface temperature measurement. This, which depending on specific conditions was found to vary between about 1 and 2 °C, was employed to demonstrate the implications and approximate conditions under which its effect could become excessively high in ordinary solar still investigations.

12/01395 Thermal and economic windows design for different climate zones

Jaber, S. and Ajib, S. *Energy and Buildings*, 2011, 43, (11), 3208–3215.

Window design, especially glazing choices, is a critical factor for determining the effectiveness of passive solar design. In this paper the effects of windows' *U*-value, window orientation and windows size on annual heating and cooling energy demand is studied considering the both energy and investment costs. The study has been performed for three different climate zones; Amman, Aqaba and Berlin. Four types of windows have been studied; single glazed, double glazed L, double glazed H and triple glazed. The results show that heating load is highly sensitive to windows size and type as compared with cooling load. Also, it is shown that with a well-optimized glazed window energy saving can be reached up to 21%, 20% and 24% for Amman, Aqaba and Berlin, respectively.

12/01396 Thermal convection in double glazed windows with structured gap

De Giorgi, L. *et al. Energy and Buildings*, 2011, 43, (8), 2034–2038.

Convective heat transfer inside the gap of double glazed windows is studied numerically using a commercial CFD code (Fluent v6.3), for different Rayleigh numbers and aspect ratios. A reference window with empty gap is compared with windows where the gap contains fins arranged in such a way as to reduce heat transfer. The effects of convective air flow inside the cavities were estimated both at the onset of convection and at steady-state in real environmental conditions. The global Nusselt numbers were calculated for different configurations of the fins in the window gap, in order to apply the standard heat loss estimation method to this type of windows.

12/01397 Use of B_2O_3 to improve Li^+-ion transport in $LiTi_2(PO_4)_3$-based ceramics

Peng, H. *et al. Journal of Power Sources*, 2012, 197, 310–313.

Substitution of B for Ti in $Li_{1+x}Ti_{2-x}B_x(PO_4)_3$ introduces x mobile Li^+ ions per formula unit in the solid-station range $0 < x \leq 0.2$. The B_2O_3 is also an aid to sintering dense ceramics with more uniform particle size. With $x = 0.2$, the room-temperature Li^+-ion conductivity is $\sigma_{Li} = 2.0 \times 10^{-4}\, S\, cm^{-1}$ with a motional activation energy of 0.48 eV. For $x > 0.2$, an intergranular B_2O_3-rich second phase impedes intergranular Li^+-ion transport.

13 ALTERNATIVE ENERGY SUPPLIES

Biofuels and bioconversion energy

12/01398 A simple device to test biodiesel process intensification

Santacesaria, E. *et al. Chemical Engineering and Processing: Process Intensification*, 2011, 50, (10), 1085–1094.

The authors studied the KOH catalysed transesterification reaction of vegetable oil with methanol in a tubular reactor filled with small spheres of stainless steel of different sizes. Three different packed bed configurations have been tested corresponding to different fluid dynamic situations. The first configuration corresponds to the tubular reactor filled with spheres of 2.5 mm of diameters; in the second configuration an opportune amount of spheres of 1 mm has been added to the mentioned spheres of 2.5 mm for filling the void volume of the octahedral cavities between the bigger spheres; in the third configuration an opportune amount of spheres of 0.39 mm has been added to spheres of 2.5 mm for filling the void volume of the tetrahedral cavities between the bigger spheres. The three mentioned configurations give place to the formation of micro-channels with an approximated size of respectively 1000 μm, 500 μm and 300 μm. These systems, subjected to fluid dynamic characterization, have shown a very high local turbulence (static mixer), in particular, when a packed bed reactor with dual size packing is used. Then, kinetic transesterification runs have been made by using the three mentioned packed bed reactors and a very high productivity has been obtained as a consequence of the induced local micro-mixing. A simplified kinetic model has been developed, which is able to describe many runs in batch conditions reported by the literature. This model resulted unsuitable to simulate the continuous runs performed in the described packed bed reactors. The conclusion is that monophasic models, often proposed in the literature, are not able to describe the kinetic behaviour of KOH catalysed transesterification in microchannels devices. At last, the described microchannels device represents, as it will be discussed, an ideal connection between a traditional tubular packed bed reactor and the recently appeared microreactors that are very efficient in mass and energy transfer operations for process intensification.

12/01399 Aerosol-based method for investigating biomass char reactivity at high temperatures

Lin, L. *et al. Combustion and Flame*, 2011, 158, (7), 1426–1437.

An aerosol-based method was proposed and developed to characterize particles fragmented from biomass chars during oxidation. The chars were prepared from both wood and miscanthus pellets under various pyrolysis conditions. Char fragments with aerodynamic diameters in the range of 0.5–10 µm were suspended and transported in a reactive gas through an aerosol reactor, which was heated by an electric oven. The oxidation of char particles in the reactor was investigated by determining on-line the particle size distributions before and after passage through the reactor using an aerodynamic particle sizer (APS) spectrometer. The interpretation of APS data was evaluated by both experiments and models in which the fine char particles were assumed to keep either constant density or constant diameter during the oxidation process. The results indicate that the aerosol-based method can be used to determine reaction kinetics of char particles in the high-temperature range, where oxidation is normally controlled by diffusion limitation if measuring with the conventional techniques. The application of the aerosol method indicated that high pyrolysis temperature and prolonged retention time will reduce the char reactivity.

12/01400 Analysis of coffee cut-stems (CCS) as raw material for fuel ethanol production

Triana, C. F. *et al. Energy*, 2011, 36, (7), 4182–4190.

Coffee cut-stems (CCS) represent a promising candidate for fuel ethanol production in tropical countries because of their high availability and high biomass yield per hectare. In this work, pretreatment of this agricultural residue with dilute sulfuric acid and liquid hot water (LHW) was integrated in the simulation and economic assessment of the process for fuel ethanol production. High reducing sugars concentration and ethanol yields were obtained with the LHW pretreatment at a high energy cost. Acid pretreatment is still one of the most applied technologies for lignocellulosic materials due to its efficiency and lower energy consumption. For the determination of the pollution environmental impact index of the process with and without cogeneration system, the waste reduction algorithm (WAR) was used. Thus, the high lignin and low water contents of the coffee cut-stems signified a high potential for energy cogeneration.

12/01401 Application of mesoporous catalysts over palm-oil biodiesel for adjusting fuel properties

Lin, C.-Y. and Cheng, H.-H. *Energy Conversion and Management*, 2012, 53, (1), 128–134.

Biodiesel has superior fuel characteristics, including a higher flash point, better lubricity, and higher oxygen content, and is thus considered a promising alternative clean fuel to petroleum diesel. The cold filter plugging point (CFPP) is the most significant indicator of the low-temperature fluidity of biodiesel. The CFPP of biodiesel is generally higher than that of petroleum diesel primarily due to the longer carbon-chain structures of the fatty acids in the former. Raw materials such as palm oil and waste cooking oil are widely used as the feedstock to produce biodiesel because of their low cost, good availability, and stable lipid provision. However, they generally have a poor low-temperature fluidity, which limits their application in colder climates. In this experimental study, the catalytic dehydrogenation and cracking reaction technique was used to reduce the CFPP of palm-oil biodiesel with an initial CFPP of as high as 14 °C. The catalytic variables of the type of mesoporous catalyst and operating temperature are considered in this study. The resultant fuel properties of palm-oil biodiesel catalysed by MCM-41 and SiO_2/Fe_3O_4 were compared with biodiesel thermally cracked without a catalyst. The operating temperature of the catalysed dehydrogenation and cracking reaction was controlled in the range between 400 and 600 °C. The CFPP decrease reached a maximum of 12 °C when the biodiesel was catalysed by SiO_2/Fe_3O_4 at 600 °C. The maximum water content was produced when the biodiesel sample was thermally cracked with no catalyst at 600 °C. Biodiesel that was catalytically dehydrogenated and cracked with MCM-41 or SiO_2/Fe_3O_4 had a higher iodine value and a lower kinematic viscosity, specific gravity, and CFPP than biodiesel cracked thermally without a catalyst. Moreover, the rate of water formation was reduced when the catalysts were used in the dehydrogenation and cracking reaction. Palm-oil biodiesel catalysed by SiO_2/Fe_3O_4 at 600 °C was found to produce the lowest CFPP (2 °C), specific gravity, and kinematic viscosity and the highest iodine value of all of the biodiesel samples studied.

12/01402 Biodiesel-derived crude glycerol bioconversion to animal feed: a sustainable option for a biodiesel refinery

Nitayavardhana, S. and Khanal, S. K. *Bioresource Technology*, 2011, 102, (10), 5808–5814.

This study examined the potential of producing an edible fungus, *Rhizopus microsporus* var. *oligosporus*, on biodiesel-derived crude glycerol. Prolific fungal growth was observed with a fungal biomass yield of 0.83 ± 0.02 (g biomass increase/g initial biomass) under optimal cultivation conditions (e.g. non-sterile crude glycerol at a concentration of 75% (w/v) with nutrient supplementation and without pH control). The potential of utilizing front-end processed banagrass (*Pennisetum purpureum*) juice as a source of nutrients for crude glycerol fermentation was evaluated with a 2.3-fold improvement in the fungal biomass yield. The glycerol-derived fungal biomass showed high amounts of threonine, one of the main limiting amino acids in non-ruminant feeds. An inexpensive fungal protein has the potential to reduce meat product prices by lowering the production costs of animal feeds. The application of fungal technology thus provides a unique sustainable option for biodiesel refineries by providing an additional source of revenue from fungal products.

12/01403 Biofuel ethanol adulteration detection using an ultrasonic measurement method

Figueiredo, M. K.-K. *et al. Fuel*, 2012, 91, (1), 209–212.

Hydrous ethanol is a biofuel used throughout the world. Brazilian regulations stipulate that the concentration of ethanol in hydrous ethanol can be accepted at a maximum concentration of 93.8% and a minimum of 92.6% by mass. The aim of this study is to identify the possible changes in hydrous ethanol fuel using ultrasonic attenuation and propagation velocity. The experiments were performed in the Laboratory of Ultrasound of the Brazilian National Institute of Metrology (Inmetro). The experiments and uncertainties in the methodology were evaluated according to the Guide to the Expression of Uncertainty in Measurement, JCGM 100:2008. The test samples used in this study were mixtures of ethanol and water with ethanol concentrations varying from 89.84% to 93.71% by mass; and a commercial fuel ethanol bought from a local distributor. The correlation coefficient between ethanol concentrations and ultrasonic propagation velocity was 0.99 (in modulus), and the maximum combined uncertainty was $0.60\,m\,s^{-1}$. Considering attenuation, the correlation coefficient was 0.97, and the maximum combined uncertainty was $0.085\,dB\,cm^{-1}$. However, its signal is not stable resulting an unreliable parameter. Within the tested concentration range, the highest concentration that is statistically different ($p < 0.002$, $\alpha = 5\%$) from 92.60% is 92.25%, considering propagation velocity as parameter. To validate the methodology, a commercial ethanol fuel was tested using the proposed method as well as the gas chromatography analytical method (gold standard). Result was statistically identical for propagation velocity when compared to the gold standard.

12/01404 Biomass and energy yield of industrial hemp grown for biogas and solid fuel

Prade, T. *et al. Biomass and Bioenergy*, 2011, 35, (7), 3040–3049.

This study examined the energy yield of hemp (*Cannabis sativa* L.) cultivated for energy purposes under cold climate conditions in northern Europe. Split-plot field trials were carried out over three consecutive years to investigate different nitrogen fertilization regimes. Dry matter yield per hectare, moisture content, hydrogen content and heating value were determined at roughly monthly intervals from July until the following spring every season. The energy yield was calculated and adjusted for a fair comparison with those of other energy crops commonly grown in the study region. Two harvest periods for optimal energy yield have been determined; harvest in September to October, when the hemp is used for biogas production, yielded $14.4\,Mg\,ha^{-1}$ and $296\,GJ\,ha^{-1}$; harvest in February to April, when the hemp is used as a solid fuel, yielded $9.9\,Mg\,ha^{-1}$ and $246\,GJ\,ha^{-1}$. For biogas production, the adjusted biomass energy yield of hemp was similar to that of maize and sugar beet and 24 and 14% greater than that of lucerne and clover-grass ley, respectively. As a solid fuel, the adjusted biomass energy yield of hemp was 120% higher than that of wheat straw and similar to that of reed canary grass. Annual variations in dry matter yield depending on weather conditions and sowing dates exceeded variations due to nitrogen fertilization. Hemp is suitable as an energy crop in cold climate regions of northern Europe, as it has similar or often higher energy yields than other common energy crops grown in these regions.

12/01405 Biomass production and nitrogen and phosphorus removal by the green alga *Neochloris oleoabundans* in simulated wastewater and secondary municipal wastewater effluent

Wang, B. and Lan, C. Q. *Bioresource Technology*, 2011, 102, (10), 5639–5644.

Biomass productivity of $350\,mg\,DCW\,L^{-1}\,day^{-1}$ with a final biomass concentration of $3.15\,g\,DCW\,L^{-1}$ was obtained with *Neochloris oleoabundans* grown in artificial wastewater at sodium nitrate and phosphate concentrations of 140 and $47\,mg\,L^{-1}$, respectively, with undetectable levels of residual N and P in effluents. In secondary municipal wastewater effluents enriched with $70\,mg\,N\,L^{-1}$, the alga achieved a final biomass concentration of 2.1 g DCW tsp;L^{-1} and a biomass productivity of $233.3\,mg\,DCW\,L^{-1}\,day^{-1}$. While N removal was very sensitive to N:P ratio, P removal was independent of N:P ratio in the tested range. These results indicate that *N. oleoabundans* could potentially be employed for combined biofuel production and wastewater treatment.

12/01406 Catalysis for conversion of biomass to fuels via pyrolysis and gasification: a review

Bulushev, D. A. and Ross, J. R. H. *Catalysis Today*, 2011, 171, (1), 1–13.

A current aim of society is to produce fuels from non-food biomass and catalysis is central to achieving this aim. Catalytic steam-reforming of biomass gives synthesis gas and this can be further transformed to give transport fuels using catalysis. Biofuels and fuel additives can also be obtained by catalytic upgrading of bio-oil produced by non-catalytic pyrolysis of biomass. This upgrading can be performed by low temperature esterification with alcohols (followed by water separation) or by high temperature gasification, cracking or hydrotreating processes. Upgraded bio-oil can also be obtained by pyrolysis of biomass in the presence of catalysts. This review considers recent trends in the chemistry of these processes for biofuel production and the catalysts used.

12/01407 Combustion chemistry and fuel-nitrogen conversion in a laminar premixed flame of morpholine as a model biofuel

Lucassen, A. *et al. Combustion and Flame*, 2011, 158, (9), 1647–1666.

The present study has been motivated by the need to understand and predict fuel-nitrogen conversion in the combustion of biomass-derived fuels. Within that broader context, an earlier related publication has investigated morpholine (C_4H_9NO, 1-oxa-4-aza-cyclohexane) as a model oxygen- and nitrogen-containing biofuel, and species identification was presented for a slightly fuel-rich $\Phi = 1.3$ ($C/O = 0.41$) laminar premixed morpholine-oxygen-argon flame at 40 mbar. To attempt a more detailed insight into the flame structure and combustion mechanism, the present contribution has now combined photoionization (PI) and electron ionization (EI) molecular-beam mass spectrometry (MBMS) to determine absolute mole-fraction profiles of numerous major and intermediate species with up to six heavy atoms. In general, PI-MBMS and EI-MBMS results were found in good agreement. The results reveal formation of a number of intermediates that may contribute to harmful emissions, including aldehydes and several nitrogen-containing compounds in percent-level concentrations. Both NH_3 and HCN pathways are seen to contribute to NO formation. To identify reaction pathways for this detailed experimental analysis, development of a flame model was started, considering a combustion mechanism for cyclohexane and analogous fuel-breakdown reactions for morpholine by addition of necessary thermodynamic, transport and kinetic parameters. The present model captures relevant features of the morpholine flame quite well, including HCN, N_2, and NO, and it can serve as a nucleus for further development of detailed combustion models for fuel-nitrogen conversion from model biofuel compounds.

12/01408 Continuous production of biodiesel from fat extracted from lamb meat in supercritical CO_2 media

Al-Zuhair, S. *et al. Biochemical Engineering Journal*, 2012, 60, 106–110.

Waste animal fat is considered a promising cheap alternative feedstock for biodiesel production that does not compete with food stock. In addition, using waste animal fat as a feedstock is considered a waste management process. In this work, an integrated process for a continuous fat extraction from lamb meat followed by enzymatic production of biodiesel in supercritical CO_2 has been developed and tested. The system simultaneously produces two valuable products, namely biodiesel and healthy low-fat lean lamb meat (HLFLM). For the enzymatic process to be feasible, lipase is preferred to be used in immobilized form, which allows easy reuse. The continuous system was operated at 200 bar and a SC-CO_2 flow of 0.5 ml min^{-1}, with extraction and transesterification temperatures of 45 °C and 50 °C, respectively. The effects of the methanol to fat (M:F) molar ratio and enzyme stability were investigated. It was found that with fresh enzyme, a M:F molar ratio of 10:1 gave the highest biodiesel production rate of 0.37 mg min^{-1} g-enzyme^{-1} compared to only 0.09 mg min^{-1} g-enzyme^{-1} using a M:F molar ratio of 5:1. However, when a M:F molar ratio of 10:1 was used, the activity of the enzyme in the third meat replacement cycle drastically dropped to 18% of its original value, compared to 79% using a M:F molar ratio of 5:1.

12/01409 Corn's cob as a potential ecological thermal insulation material

Pinto, J. *et al. Energy and Buildings*, 2011, 43, (8), 1985–1990.

Tabique construction is one of the main Portuguese traditional building techniques that use earth based building materials. It is peculiar building technique which uses corn cobs as a filling material for the external tabique walls. The existing tabique construction in Trás-os-Montes e Alto Douro region of north-east Portugal was studied to learn from it for modern-day construction. The research showed that corn cobs, an agricultural waste, have the potential to be used as a sustainable building material for thermal insulation. An experimental work concluded that there are significant similarities between corn cobs and the extruded polystyrene material in terms of microstructure and chemical composition. Furthermore, the results obtained from an expeditious experimental thermal procedure indicate that corn cobs may have adequate thermal properties for building purpose.

12/01410 Effect of steam explosion pretreatment with ultra-high temperature and pressure on effective utilization of softwood biomass

Asada, C. *et al. Biochemical Engineering Journal*, 2012, 60, 25–29.

Effective utilization process of not only cellulose but also lignin contained in softwood biomass into useful fuel and materials was developed using steam explosion with ultra-high temperature and pressure steam, extraction and various conversion methods. The conversion of softwood biomass into useful materials was studied for the effective utilization of its components such as cellulose, water soluble material, methanol soluble lignin, and Klason lignin. The cellulose, water soluble material, methanol soluble lignin, and Klason lignin were converted into useful fuel and materials, i.e. ethanol, antioxidant material, lignin epoxy resin, and activated carbon, respectively. 49.6 g of glucose or 17.4 g of ethanol was obtained from 100 g of steam-exploded product treated at a steam pressure of 45 atm and 3 min. Water soluble material had a comparatively high antioxidant activity and methanol soluble lignin was converted into a cured epoxy resin with heat-resisting property for solder demanded in the electronic material field.

12/01411 Efficient preparation of biodiesel from rapeseed oil over modified CaO

Tang, Y. *et al. Applied Energy*, 2011, 88, (8), 2735–2739.

In this study, the catalytic performance of commercial CaO modified by trimethylchlorosilane (TMCS) for transesterification of rapeseed oil and methanol to biodiesel production was investigated. It was found that the fatty acid methyl esters (FAME) yield of the modified CaO was greatly enhanced from 85.4% to 94.6%. The possible reason lies on promoting the absorption of grease to CaO surface. Good results of repeated experiments showed that the modified catalyst has the capacity of water resistance and can be reused for several runs without significant deactivation, which can be confirmed by the humidity test in the vapour-saturated atmosphere. Both the characterizations of the catalyst and the effects of various factors such as mass ratio of catalyst to oil, reaction temperature and molar ratio of methanol to oil were investigated.

12/01412 Emissions from soy biodiesel blends: a single particle perspective

Dutcher, D. D. *et al. Atmospheric Environment*, 2011, 45, (20), 3406–3413.

Biodiesel has recently re-emerged as a common fuel. However, emissions from biodiesel combustion have been studied in much less detail than those from traditional petroleum-based diesel. In this experiment, emissions from the combustion of different fuel blends (B00, B02, B20, B99, where the number after B indicates the percentage, by volume, of biodiesel in the fuel) in a VW TDi engine were analysed by aerosol time-of-flight mass spectrometers (ATOFMS) for single-particle composition and vacuum aerodynamic size. The ATOFMS results show that the PAH molecular weight distribution is not significantly affected by the fuel composition, and that sulfates are reduced by increased biodiesel content. Octanedioic acid (a carbonyl species) is increased with increased biodiesel concentration. Clustering results from the single-particle spectra show that the particles fall in five main types by chemical composition. The aerodynamic size distribution of these individual clusters was also determined. These results also show that methods used to identify diesel particle emissions for source apportionment are not applicable when significant concentrations of biodiesel are used in fuels.

12/01413 Ethanol production from oil palm trunks treated with aqueous ammonia and cellulase

Jung, Y. H. *et al. Bioresource Technology*, 2011, 102, (15), 7307–7312.

Oil palm trunks are a possible lignocellulosic source for ethanol production. Low enzymatic digestibility of this type of material (11.9% of the theoretical glucose yield) makes pretreatment necessary. An enzymatic digestibility of 95.4% with insoluble solids recovery of 49.8% was achieved after soaking shredded oil palm trunks in ammonia under optimum conditions (80 °C, 1:12 solid-to-liquid ratio, 8 h and 7% (w/w) ammonia solution). Treatment with 60 FPU of commercial cellulase (Accellerase 1000) per gram of glucan and fermentation with *Saccharomyces cerevisiae* D_5A resulted in an ethanol concentration of 13.3 g/L and an ethanol yield of 78.3% (based on the theoretical maximum) after 96 h. These results indicate that oil palm trunks are a biomass feedstock that can be used for bioethanol production.

12/01414 Examining the potential for liquid biofuels production and usage in Ghana

Afrane, G. *Energy Policy*, 2012, 40, 444–451.

The perennial political and social upheavals in major oil-producing regions, the increasing energy demand from emerging economies, the global economic crisis and even environmental disasters, like the recent major oil spill in the Gulf of Mexico, all contribute to price fluctuations and escalations. Usually price instability affects the least-developed countries with the most fragile economies, like Ghana, the most. This paper gives a brief overview of the Ghanaian energy situation, describes the liquid biofuel production processes and examines the possibility of replacing some of the fossil fuels consumed annually, with locally produced renewable biofuels. Various scenarios for substituting different portions of petrol and diesel with biofuels derived from cassava and palm oil are examined. Based on 2009 crop production and fuel consumption data, replacement of 5% of both petrol and diesel with biofuels would require 1.96% and 17.3% of the cassava and palm oil produced in that year, respectively; while replacement of 10% of both fossil fuels would need 3.91% and 34.6% of the corresponding biofuels. Thus while petrol replacement could be initiated with little difficulty, regarding raw material availability, biodiesel would require enhanced palm oil production and/or oil supplement from other sources, including, potentially, jatropha. An implementation strategy is proposed.

12/01415 Fundamental performance of novel power supply for HTS magnet using solar energy system

Chung, Y. D. *et al. Cryogenics*, 2011, 51, (6), 220–224.

This study proposes a novel superconducting power supply that is combined with superconducting power supply and solar energy system. An eternal electric energy can be converted by solar energy system, which contains solar panel, photovoltaic (PV) controller and energy-storing battery, can be utilized in the utility power of superconducting power applications. The novel power supply could operate without external utility power to charge the HTS load magnet due to the solar energy. The operating efficiency can be improved and installed in remote locations where utility power is not available. In this paper, as a first step of this work, the authors showed the possibility of technical fusion between a superconducting power supply and a solar energy system.

12/01416 Influence of particle size and chemical composition on the performance and kinetics of anaerobic digestion process of sunflower oil cake in batch mode

De la Rubia, M. A. *et al. Biochemical Engineering Journal*, 2011, 58–59, 162–167.

Biochemical methane potential (BMP) assays of sunflower oil cake (SuOC) were carried out to research the effect of different particle sizes and their chemical composition on methane yields and kinetics. Particle size ranges of (1) 0.355–0.55 mm, (2) 0.710–1.0 mm and (3) 1.4–2.0 mm in diameter were evaluated. The highest methane yield $213 \pm 8\,\mathrm{mL\,CH_4\,g^{-1}\,VS_{added}}$ was obtained for the largest particle size analysed (3), against $186 \pm 6\,\mathrm{mL\,CH_4\,g^{-1}\,VS_{added}}$ obtained for particles 1 and 2. This may be attributed to the different lignocellulose compositions of the various particle size ranges studied and to organic matter removals (47.2% for 3, against ~41.5% for 1 and 2). The evolution of propionic acid concentration was found to be fundamental for explaining the lowest rate of biogas production for the smallest (1) particle size studied, with a specific rate constant k of $0.45 \pm 0.02\,\mathrm{d^{-1}}$, while values of $0.61 \pm 0.02\,\mathrm{d^{-1}}$ and $0.50 \pm 0.01\,\mathrm{d^{-1}}$ were obtained for particles 2 and 3, respectively.

12/01417 Integrated biomass gasification combined cycle distributed generation plant with reciprocating gas engine and ORC

Kalina, J. *Applied Thermal Engineering*, 2011, 31, (14–15), 2829–2840.

The paper theoretically investigates the performance of a distributed generation plant made up of gasifier, internal combustion engine (ICE) and organic Rankine cycle (ORC) machine as a bottoming unit. The system can be used for maximization of electricity production from biomass in the case where there is no heat demand for cogeneration plant. To analyse the performance of the gasifier a model based on the thermodynamic equilibrium approach is used. Performance of the gas engine is estimated on the basis of the analysis of its theoretical thermodynamic cycle. Three different setups of the plant are being examined. In the first one the ORC module is driven only by the heat recovered from engine exhaust gas and cooling water. Waste heat from a gasifier is used for gasification air preheating. In the second configuration a thermal oil circuit is applied. The oil transfers heat from engine and raw gas cooler into the ORC. In the third configuration it is proposed to apply a double cascade arrangement of the ORC unit with a two-stage low temperature evaporation of working fluid. This novel approach allows utilization of the total waste heat from the low temperature engine cooling circuit. Two gas engines of different characteristics are taken into account. The results obtained were compared in terms of electric energy generation efficiency of the system. The lowest obtained value of the efficiency was 23.6% while the highest one was 28.3%. These are very favourable values in comparison with other existing small and medium scale biomass-fuelled power generation plants.

12/01418 Ionic liquid assisted enzymatic delignification of wood biomass: a new 'green' and efficient approach for isolating of cellulose fibers

Moniruzzaman, M. and Ono, T. *Biochemical Engineering Journal*, 2012, 60, 156–160.

The objective of this study was to provide a new environmentally friendly and efficient approach for isolating cellulose fibres with minimum structural alteration from wood biomass. The method comprised enzymatic delignification of ionic liquid (IL) swollen wood biomass in ILs–aqueous systems with the aim of overcoming low delignification efficiency associated with the difficulties in enzyme accessibility to the solid substrate and the poor substrate and products solubility in aqueous system. It was found that the cellulose rich wood fibres obtained from biological pretreatment in IL–aqueous systems contained significantly lower amounts of lignin as compared to those found in conventional methods. The treated wood fibres were characterized using Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), thermogravimetric analysis (TGA) and X-ray diffractometry (XRD) and compared those with untreated wood fibres.

12/01419 Model-size reduction techniques for large-scale biomass production and supply networks

Lam, H. L. *et al. Energy*, 2011, 36, (8), 4599–4608.

This paper is concerned with developing several model-size reduction techniques for the analysis of large-scale renewable production and supply networks. They are: (i) reducing the connectivity in a biomass supply chain network, (ii) eliminating unnecessary variables and constraints, and (iii) merging the collection centres. The proposed model-size reduction techniques brought computational time improvements of several magnitudes compared, with the high-performance linear system solution techniques and still with a little loss in accuracy. When the methods are combined the time reductions are more significant. A proposed procedure for combining the methods can be implemented for any supply chain model with a large number of components.

12/01420 Modeling the effect of mixing in biodiesel production

Brásio, A. S. R. *et al. Bioresource Technology*, 2011, 102, (11), 6508–6514.

The transesterification reaction models available in the literature are valid only for one particular mixing condition. In this work, a modelling strategy is presented in order to predict the effect of mixing conditions in the transesterification process. The proposed methodology was applied to independent sets of experimental data available in the literature that show the dependency of the transesterification reaction on the frequency of rotation of the stirrer. The accuracy of the developed models corroborates the validity of the proposed modelling approach.

12/01421 New thermal insulation boards made from coconut husk and bagasse

Panyakaew, S. and Fotios, S. *Energy and Buildings*, 2011, 43, (7), 1732–1739.

This study describes the production of low density thermal insulation boards made from coconut husk and bagasse without the use of chemical binding additives. Dwelling in Thailand use thermal insulation to reduce air conditioning loads; the aim of this study was to develop a thermal insulation with lower environmental footprint than conventional materials. The hot pressing method was used and this article reports on the effect of board density and pressing conditions on the properties of the insulation boards. Mechanical properties of the coconut husk and bagasse insulation boards were measured for comparison with the standard employed in Thailand (JIS A 5905: 2003 Insulation Fibreboards). It was found that the bagasse insulation board with a density of $350\,\mathrm{kg/m^3}$, using a 13 min pressing time at a temperature of 200 °C, met all of the requirements except for swelling thickness. Thermal conductivity of the coconut husk and bagasse insulation boards was measured according to ISO 8301 and this suggested that both insulation boards have thermal conductivity values ranging from 0.046 to 0.068 W/mK which were close to those of conventional insulation materials such as cellulose fibres and mineral wool.

12/01422 Oil production by oleaginous yeasts using the hydrolysate from pretreatment of wheat straw with dilute sulfuric acid

Yu, X. *et al. Bioresource Technology*, 2011, 102, (10), 6134–6140.

This paper explores the use of the hydrolysate from the dilute sulfuric acid pretreatment of wheat straw for microbial oil production. The resulting hydrolysate was composed of pentoses (24.3 g/L) and hexoses (4.9 g/L), along with some other degradation products, such as acetic acid, furfural, and *hydroxymethylfurfural* (HMF). Five oleaginous yeast strains, *Cryptococcus curvatus*, *Rhodotorula glutinis*, *Rhodosporidium toruloides*, *Lipomyces starkeyi*, and *Yarrowia lipolytica*, were evaluated by using this hydrolysate as substrates. The results showed that all of these strains could use the detoxified hydrolysate to produce lipids while except *R. toruloides* non-detoxified hydrolysate could also be used for the growth of all of the selective yeast strains. *C. curvatus* showed the highest lipid concentrations in medium on both the detoxified (4.2 g/L) and non-detoxified (5.8 g/L) hydrolysates. And the inhibitory effect studies on *C. curvatus* indicated HMF had insignificant impacts at a concentration of up to 3 g/L while furfural inhibited cell growth and lipid content by 72.0% and 62.0% at 1 g/L, respectively. This work demonstrates that lipid production is a promising alternative to utilize hemicellulosic sugars obtained during pretreatment of lignocellulosic materials.

12/01423 Optimal plant size and feedstock supply radius: a modeling approach to minimize bioenergy production costs

Gan, J. and Smith, C. T. *Biomass and Bioenergy*, 2011, 35, (8), 3350–3359.

Bioenergy production involves a series of interrelated activities associated with feedstock production and feedstock-to-energy conversion. Thus, decisions on bioenergy production and deployment should be based on the simultaneous consideration of the entire supply chain. Based on cost minimization of both feedstock production and energy conversion, a generic framework is developed for determining the optimal bioenergy conversion plant size, the corresponding feedstock supply radius, and bioenergy production costs. The theoretical framework elucidates the relationships among activities along the bioenergy supply chain, suggesting strategies for enhancing the cost competitiveness of bioenergy. Such relationships as well as applications of the theoretical model are further illustrated using cases of producing electricity and cellulosic ethanol from biomass.

12/01424 Performance evaluation of a constant speed IC engine on CNG, methane enriched biogas and biogas

Chandra, R. *et al. Applied Energy*, 2011, 88, (11), 3969–3977.

This paper presents the performance results of a 5.9 kW stationary diesel engine which was converted into spark ignition mode and run on compressed natural gas (CNG), methane-enriched biogas (Bio-CNG) and biogas produced from biomethanation of jatropha and pongamia oil seed cakes. The performance of the engine with 12.65 compression ratio was evaluated at 30°, 35° and 40° ignition advance of TDC. The maximum brake power produced by the engine was found at ignition advance of 35° TDC for all the tested fuels. In comparison to diesel as original fuel, the power deteriorations of the engine was observed to be 31.8%, 35.6% and 46.3% on compressed natural gas, methane enriched biogas and raw biogas, respectively, due to its conversion from CI to SI mode. The methane enriched biogas showed almost similar engine performance as compared to compressed natural gas in terms of brake power output, specific gas consumption and thermal efficiency.

12/01425 Predicting cetane number, kinematic viscosity, density and higher heating value of biodiesel from its fatty acid methyl ester composition

Ramírez-Verduzco, L. F. *et al. Fuel*, 2012, 91, (1), 102–111.

Biodiesel is a renewable bio-fuel derived from natural fats or vegetable oils, and it is considered as a promising alternative to substitute diesel fuels. Cetane number, viscosity, density, and higher heating value are important properties to affect the utilization of biodiesel fuels, because they are involved in the definition of fuel quality and are required as input data for predictive engine combustion models. This work presents the characterization of two biodiesel samples made from beef tallow and soybean oil through their fatty acid methyl esters (FAMEs) profile. Empirical equations were developed to estimate four physical properties of methyl esters; and an average absolute deviation (AAD) of 5.95%, 2.57%, 0.11% and 0.21% for the cetane number, kinematic viscosity, density, and higher heating value were founded. Cetane number, viscosity, and higher heating value increases because of the increase of molecular weight and these physical properties decrease as the number of double bonds increases. Unlike that of above properties, density decreases as molecular weight increases and density increases as the degree of unsaturation increases. Two general mixing rules and five biodiesel samples were used to study the influence of FAMEs over the physical properties of biodiesel. The prediction of the cetane number, kinematic viscosity, density and higher heating value of biodiesel is very close to the experimental values.

12/01426 Production of hydrocarbon fuels from biomass using catalytic pyrolysis under helium and hydrogen environments

Thangalazhy-Gopakumar, S. *et al. Bioresource Technology*, 2011, 102, (12), 6742–6749.

This study is focused on hydrocarbon production through changing carrier gas and using zeolite catalysts during pyrolysis. A large reduction in high molecular weight, oxygenated compounds was noticed when the carrier gas was changed from helium to hydrogen during pyrolysis. A catalytic pyrolysis was conducted using two different methods based on how the biomass and catalysts were contacted together. For both methods, there was no significant change in the carbon yield with the change in pyrolysis environment. However, the mixing-method produced higher aromatic hydrocarbons than the bed-method. In addition, two methods were also tested using two ratios of biomass to catalyst. Nonetheless, there was no significant increase in hydrocarbon yield as the catalyst loading was increased from two to five times of biomass in the catalyst-bed method. In contrast to this, a significant increase was noticed for the catalytic-mixing method when the biomass to catalyst loading was increased from 1:4 to 1:9.

12/01427 Productivity, carbon dioxide uptake and net energy return of microalgal bubble column photobioreactors

Hulatt, C. J. *et al. Bioresource Technology*, 2011, 102, (10), 5775–5787.

This work examined the energy return of *Chlorella vulgaris* and *Dunaliella tertiolecta* cultivated in a gas-sparged photobioreactor design where the power input for sparging was manipulated (10, 20, and 50 W m^{-3}). Dry weight, organic carbon and heating values of the biomass were measured, plus a suite of variables including Fv/Fm and dissolved oxygen. A model for predicting the higher heating value of microalgal biomass was developed and used to measure the energetic performance of batch cultivations. High power inputs enhanced maximum biomass yields, but did not improve the energy return. Cultivation in 10 W m^{-3} showed up to a 39% higher cumulative net energy return than 50 W m^{-3}, and increased the cumulative net energy ratio up to fourfold. The highest net energy ratio for power input was 19.3 (*D. tertiolecta*, 12% CO_2, 10 W m^{-3}). These systems may be a sustainable method of biomass production, but their effectiveness is sensitive to operational parameters.

12/01428 Refining technologies for the purification of crude biodiesel

Atadashi, I. M. *et al. Applied Energy*, 2011, 88, (12), 4239–4251.

In biodiesel production, downstream purification is an important step in the overall process. This article is a critical review of the most recent research findings pertaining to biodiesel refining technologies. Both conventional refining technologies and the most recent biodiesel membrane refining technology are reviewed. The results obtained through membrane purification showed some promise in term of biodiesel yield and quality. Also, membranes presented low water consumption and less wastewater discharges. Therefore, exploration and exploitation of membrane technology to purify crude biodiesel is necessary. Furthermore, the success of membrane technology in the purification of crude biodiesel could serve as a boost to both researchers and industries in an effort to achieve high purity and quality biodiesel fuel capable of replacing non-renewable fossil fuel, for wide range of applications.

12/01429 Screening of marine microalgae for biodiesel feedstock

Doan, T. T. Y. *et al. Biomass and Bioenergy*, 2011, 35, (7), 2534–2544.

Biodiesel production from microalgae lipids is increasingly regarded as a more sustainable and feasible alternative to conventional biodiesel feedstocks derived from terrestrial bioenergy crops. A total of 96 strains of marine microalgae, with an elevated biomass productivity and intracellular lipid content, were isolated from the coastal waters of Singapore using an automated flow cytometric cell-sorting technique. Cell sorting was based on the two-dimensional distribution of algal cells for red fluorescence (representing chlorophyll auto-fluorescence) against forward-light scatter (representing cell size) and red vs green fluorescence. Twenty-one of the strains were further characterized with respect to cell growth rate, biomass concentration, lipid content (total and neutral lipid) and fatty acid profile. The growth rates of *Skeletonema costatum*, *Chaetoceros* and *Thalassiosira* species were greatest among the entire strains, but in terms of absolute lipid yield *Nannochloropsis* strains predominated. *Nannochloropsis* strains had a lipid content ranging from 39.4% to 44.9% of dry weight biomass. Transesterification of the lipids yielded 25–51% of fatty acid methyl ester (FAME), i.e. biodiesel, where total FAME content ranged between 11 and 21% of dry weight biomass. This study describes the microalgae screening process and demonstrates that *Nannochloropsis* is a promising species for biodiesel feedstock.

12/01430 Synthesis and parameter optimization of a combined sugar and ethanol production process integrated with a CHP system

Morandin, M. *et al. Energy*, 2011, 36, (6), 3675–3690.

The combined sugar and ethanol production process from sugar cane is a paradigmatic application for energy integration strategies because of the high number of hot and cold streams involved, the external hot utility requirement at two temperature levels for juice evaporation and crystallization, and the electricity demand for juice extraction by milling. These conditions make it convenient to combine the sugarcane process with a CHP system fuelled by bagasse, the main by-product from juice extraction. The strategies, tools and expertise on energy integration developed separately by the research teams authoring this paper are applied here jointly to optimize the synthesis and the design parameters of the process and of the total site starting from the basic idea of dissociating the heat exchanger network design problem from the total site synthesis problem. At first the minimization of the external heat requirement for the process alone is pursued and results show that a one third reduction can be achieved by optimal heat integration. Then the use of the by-product bagasse for on-site power generation is considered and two bagasse-fuelled CHP systems are optimized along with some parts of the sugar and ethanol production process in order to obtain maximum total site net power. Results show a variety of interesting scenarios of combined sugar, ethanol and electricity production plants with considerably high electricity output.

12/01431 The reactivity of mesoporous silica modified with acidic sites in the production of biodiesel

Sherry, L. and Sullivan, J. A. *Catalysis Today*, 2011, 175, (1), 471–476.

The authors studied a range of acidic catalysts prepared through the modification of mesoporous silica materials. Specifically they prepared –SO_3H modified materials (in the presence and absence of a hydrophobic component) and –COOH and –CN materials. The authors have characterized these catalysts using TEM, TGA, TPD of probe molecules and IR and have analysed their activity in the esterification of octanoic acid and the transesterification of triacetin. Activity in the esterification reaction (in which all catalysts are active) is not determined by the acid site concentration of the catalyst while the activity of active catalysts in the transesterification reaction (in which only –SO_3H materials are active) appears related to acid site concentration.

12/01432 Trace compounds affecting biogas energy utilisation – a review

Rasi, S. *et al. Energy Conversion and Management*, 2011, 52, (12), 3369–3375.

This paper investigates the trace compounds affecting energy utilization in biogas that come from different production sites. With biogas being more widely used in different energy applications more interest has arisen for the specific composition of biogas. In traditional energy applications, methane and hydrogen sulfide contents have had the most influence when energy utilization application has been considered. With more advanced processes also the quantity and quality of trace compounds is more important. In regards to trace compounds, it was found that the concentrations and the variations of volatile organic compounds (VOCs) can be high in different landfills, especially, with compounds originating from the biological degradation process (like aromatics and terpenes) as seasonal variations affect the biological degradation. Trace compounds produced by direct volatilization (halogenated and silicon compounds) show a smaller seasonal variation. Halogenated compounds are rarely present in high concentrations in waste water treatment plant (WWTP) biogas, but the concentrations of organic silicon compounds and their variation is high. Organic silicon compounds are usually detected only in low concentrations in co-digestion plant biogas, when no WWTP sludge is used as a raw material.

12/01433 Trends, temporal and spatial characteristics, and uncertainties in biomass burning emissions in the Pearl River Delta, China

He, M. *et al. Atmospheric Environment*, 2011, 45, (24), 4051–4059.

Multi-year inventories of biomass burning emissions were established in the Pearl River Delta (PRD) region for the period 2003–2007 based on the collected activity data and emission factors. The results indicated that emissions of sulfur dioxide (SO_2), nitrogen oxide (NO_x), ammonia (NH_3), methane (CH_4), organic carbon (OC), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), and fine particulate matter ($PM_{2.5}$) presented clear declining trends. Domestic biofuel burning was the major contributor, accounting for more than 60% of the total emissions. The preliminary temporal profiles were established with MODIS fire count information, showing that higher emissions were observed in winter (from November to March) than other seasons. The emissions were spatially allocated into grid cells with a resolution of 3 km × 3 km, using GIS-based land use data as spatial surrogates. Large amount of emissions were observed mostly in the less developed areas in the PRD region. The uncertainties in biomass burning emission estimates were quantified using Monte Carlo simulation; the results showed that there were higher uncertainties in organic carbon (OC) and elemental carbon (EC) emission estimates, ranging from −71% to 133% and −70% to 128%, and relatively lower uncertainties in SO_2, NO_x and CO emission estimates. The key uncertainty sources of the developed inventory included emission factors and parameters used for estimating biomass burning amounts.

12/01434 Utilization of sugarcane bagasse for bioethanol production: sono-assisted acid hydrolysis approach

Velmurugan, R. and Muthukumar, K. *Bioresource Technology*, 2011, 102, (14), 7119–7123.

In this study, the production of sugar monomers from sugarcane bagasse (SCB) by sono-assisted acid hydrolysis was performed. The SCB was subjected to sono-assisted alkaline pretreatment. The cellulose and hemicellulose recovery observed in the solid content was 99% and 78.95%, respectively and lignin removal observed during the pretreatment was about 75.44%. The solid content obtained was subjected to sono-assisted acid hydrolysis. Under optimized conditions, the maximum hexose and pentose yield observed was 69.06% and 81.35% of theoretical yield, respectively. The hydrolysate obtained was found to contain very less inhibitors, which improved the bioethanol production and the ethanol yield observed was 0.17 g/g of pretreated SCB.

12/01435 Utilization of waste freshwater mussel shell as an economic catalyst for biodiesel production

Hu, S. *et al. Biomass and Bioenergy*, 2011, 35, (8), 3627–3635.

An economic and environmentally friendly catalyst derived from waste freshwater mussel shell (FMS) was prepared by a calcination-impregnation-activation method, and it was applied in transesterification of Chinese tallow oil. The as-prepared catalyst exhibits a 'honeycomb'-like structure with a specific surface area of $23.2\,m^2\,g^{-1}$. The newly formed CaO crystals are major active phase of the catalyst. The optimal calcination and activity temperature are 900 °C and 600 °C, respectively. When the reaction is carried out at 70 °C with a methanol/oil molar ratio of 12:1, a catalyst concentration of 5% and a reaction time of 1.5 h, the FMS-catalyst is active for seven reaction cycles, with the biodiesel yield above 90%. The experimental results indicate that the FMS can be used as an economic catalyst for the biodiesel production.

Geothermal energy

12/01436 A model of groundwater seepage and heat transfer for single-well ground source heat pump systems

Ni, L. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2622–2630.

In China, for the limitation of land, many buildings intending to utilize ground source heat pump systems install 'single-well' systems, which drill only one well for both the pumping and reinjection of the groundwater. A model of groundwater seepage and heat transfer for single-well ground source heat pump systems has been established and validated against the experiment conducted in Denmark. In a unitary homogenous confined aquifer, the analytic seepage solution has been derived. Moreover, equations of steady drawdown, seepage velocity, quasi-steady time and hydraulic effective radius are achieved. Results show that groundwater seepage can achieve steady state quickly. In addition, the thermal performance of groundwater and aquifer on a case study in Beijing, China has been simulated. The simulation indicates that the large thermal effective radius (far to 40 m), which is much larger than that of ground-coupled heat pump, makes one single-well accommodate large space heating and cooling loads.

12/01437 A survey of the induced seismic responses to fluid injection in geothermal and CO_2 reservoirs in Europe

Evans, K. F. *et al. Geothermics*, 2012, 41, 30–54.

The paper documents 41 European case histories that describe the seismogenic response of crystalline and sedimentary rocks to fluid injection. It is part of an on-going study to identify factors that have a bearing on the seismic hazard associated with fluid injection. The data generally support the view that injection in sedimentary rocks tends to be less seismogenic than in crystalline rocks. In both cases, the presence of faults near the wells that allow pressures to penetrate significant distances vertically and laterally can be expected to increase the risk of producing felt events. All cases of injection into crystalline rocks produce seismic events, albeit usually of non-damaging magnitudes, and all crystalline rock masses were found to be critically stressed, regardless of the strength of their seismogenic responses to injection. Thus, these data suggest that criticality of stress, while a necessary condition for producing earthquakes that would disturb (or be felt by) the local population, is not a sufficient condition. The data considered here are not fully consistent with the concept that injection into deeper crystalline formations tends to produce larger magnitude events. The data are too few to evaluate the combined effect of depth and injected fluid volume on the size of the largest events. Injection at sites with low natural seismicity, defined by the expectation that the local peak ground acceleration has less than a 10% chance of exceeding 0.07 g in 50 years, has not produced felt events. Although the database is limited, this suggests that low natural seismicity, corresponding to hazard levels at or below 0.07 g, may be a useful indicator of a low propensity for fluid injection to produce felt or damaging events. However, higher values do not necessarily imply a high propensity.

12/01438 An optimal control algorithm for borehole thermal energy storage systems

De Ridder, F. *et al. Energy and Buildings*, 2011, 43, (10), 2918–2925.

The aim of this paper is to present an optimal control algorithm to manage borehole thermal energy storage systems (BTES). Such a system gets exhausted, if it is employed intensively, i.e. outlet fluid is outside acceptable temperature ranges, and can no longer provide the desired heat or cold. To avoid this problem a control algorithm is proposed, which simultaneously optimizes the operation costs. This algorithm is based on a dynamic programming technique and results in an array which provides the optimal heat flux for a given field temperature, date and demand. The controller is illustrated on a simulation of an existing building. Several weather scenarios have been examined and the system remained robust under all situations.

12/01439 ANN based optimization of supercritical ORC-Binary geothermal power plant: Simav case study

Arslan, O. and Yetik, O. *Applied Thermal Engineering*, 2011, 31, (17–18), 3922–3928.

Artificial neural network (ANN) is a new tool, which works rapidly for decision making and modelling of the processes within the expertise. Therefore, ANN can be a solution for the design and optimization of complex power cycles, such as ORC-binary. In the present study, the back-propagation learning algorithm with three different variants, namely Levenberg–Marguardt (LM), Pola-Ribiere conjugate gradient (CGP), and scaled conjugate gradient (SCG) were used in the network to find the best approach. The most suitable algorithms found were LM 16 for s1 type cycle and LM 14 for s2 type cycle. The organic Rankine cycle (ORC) uses organic fluids as a working fluids and this process allows the use of low temperature heat sources and offers an advantageous efficiency in small-scale concepts. The most profitable cycle is obtained with a benefit of US$124.88 million from s1 type supercritical ORC-binary plant with an installed capacity of 64.2 MW when the working fluid is R744 and the design parameters of T_{1b}, T_{2a} and P_{2a} are set to 80 °C, 130 °C and 12 MPa, respectively.

12/01440 Application of selected geothermometers to Continental Intercalaire thermal water in southern Tunisia

Kamel, S. *Geothermics*, 2012, 41, 63–73.

The aquifer system in the Tunisian Chotts region is composed mainly of two aquifers: the upper confined/unconfined Complexe Terminal and the deeper confined Continental Intercalaire aquifer. The deep Continental Intercalaire thermal water represents approximately 20% of agricultural water supply in southern Tunisia. Its temperature varies between 46 and 73 °C, and it is mainly used for heating greenhouses and irrigation of oases. The non-thermal water (20–35 °C) is pumped from the Complexe Terminal aquifer with an average depth of 300 m. The Continental Intercalaire geothermal field is generally considered a thermal energy resource and should be evaluated for adequate purposes in the study area. Different chemical geothermometers were used in this work to assess the highest temperature that can be found in the Continental Intercalaire aquifer. Temperature values varying between 95 and 133 °C were obtained by using a Na–Li geothermometer. The multiple mineral equilibrium approach yielded a temperature of 87 to 112 °C.

12/01441 Candidate radial-inflow turbines and high-density working fluids for geothermal power systems

Sauret, E. and Rowlands, A. S. *Energy*, 2011, 36, (7), 4460–4467.

Optimization of organic Rankine cycles (ORCs) for binary-cycle geothermal applications could play a major role in determining the competitiveness of low to moderate temperature geothermal resources. Part of this optimization process is matching cycles to a given resource such that power output can be maximized. Two major and largely interrelated components of the cycle are the working fluid and the turbine. Both components need careful consideration: the selection of working fluid and appropriate operating conditions as well as optimization of the turbine design for those conditions will determine the amount of power that can be extracted from a resource. In this paper, the authors present the rationale for the use of radial-inflow turbines for ORC applications and the preliminary design of several radial-inflow machines based on a number of promising ORC systems that use five different working fluids: R134a, R143a, R236fa, R245fa and n-pentane. Preliminary meanline analysis lead to the generation of turbine designs for the various cycles with similar efficiencies (77%) but large differences in dimensions (139–289 mm rotor diameter). The highest performing cycle, based on R134a, was found to produce 33% more net power from a 150 °C resource flowing at 10 kg/s than the lowest performing cycle, based on n-pentane.

12/01442 Coupling of geothermal heat pumps with thermal solar collectors using double U-tube boreholes with two independent circuits

Eslami-nejad, P. and Bernier, M. *Applied Thermal Engineering*, 2011, 31, (14–15), 3066–3077.

This study presents an analytical model to predict steady-state heat transfer in double U-tube boreholes with two independent circuits operating with unequal mass flow rates and inlet temperatures. The model predicts the fluid temperature profiles in both circuits along the borehole depth. It accounts for fluid and pipe thermal resistance and thermal interaction among U-tube circuits. The proposed model is used to study a novel double U-tube borehole configuration with one circuit linked to a ground-source heat pump operating in heating mode and the other to thermal solar collectors. The performance of this configuration is compared to a conventional ground-source heat pump system (without thermal recharge of the borehole) and to a single-circuit solar assisted ground-source heat pump system. All three systems are simulated over a 20-year period for a residential-type single-borehole configuration. Results indicate that winter solar recharging, either for the proposed configuration or the solar assisted ground-source heat pump system, reduces by 194 and 168% the amount of energy extracted from the ground by the heat pump. It is also shown that, for a ground thermal conductivity of 1.5 W m^{-1} K^{-1}, the borehole length can be reduced by up to 17.6%, and 33.1% when the proposed configuration or the solar assisted ground-source heat pump system are used. The impact on the annual heat pump energy consumption is less dramatic with corresponding reductions of 3.5% and 6.5%.

12/01443 Deep structure investigations of the geothermal field of the North Euboean Gulf, Greece, using 3-D local earthquake tomography and Curie point depth analysis

Karastathis, V. K. *et al. Journal of Volcanology and Geothermal Research*, 2011, 206, (3–4), 106–120.

New findings on the deep origin of the geothermal field and volcanic centres at the North Euboean Gulf (or North Evian Gulf), central Greece, were obtained by combining a three-dimensional travel-time inversion of microseismic data recorded by an on/offshore local seismic network with a Curie point depth analysis based on aeromagnetic data. A magma chamber was detected from low seismic P-wave velocity values and high Poisson ratios at depths below 8 km also coincident with a Curie surface estimated at 7–8 km depth. Furthermore, it was also observed that local geothermal anomalies are generated by hydrothermal flux facilitated by NW–SE and NE–SW oriented faults. Microseismic activity is also associated with these fault systems.

12/01444 Effects of multiple ground layers on thermal response test analysis and ground-source heat pump simulation

Lee, C. K. *Applied Energy*, 2011, 88, (12), 4405–4410.

A modified three-dimensional finite difference model for the borehole ground heat exchangers of a ground-source heat pump (GSHP) system was developed which accounted for multiple ground layers with different thermal properties in the borefield at no groundwater flow. The present model was used to investigate the impact of ignoring ground layers in the thermal response test (TRT) analysis and the subsequent system simulation. It was found that the adoption of an effective ground thermal conductivity and an effective ground volumetric heat capacity for a multi-layer ground determined from a TRT analysis led to very little error in the simulated long term system performance under various ground compositions investigated. The maximum difference occurred for a 3×3 borefield in a dual-layer ground which measured 0.5 °C or 3.9% in the rise of the borefield fluid leaving temperature with a cooling-dominated loading profile for 10 years. With the same borefield and ground composition, a dynamic simulation of the complete GSHP system was performed using the TRNSYS simulation software. It was found that the overall system performance based on the present and the old models differed very little. It was concluded that the assumption of a homogeneous ground in a TRT analysis and subsequent system simulation was appropriate and impact of ignoring ground layers was small. A single-ground-layer model, including the analytical models, was sufficient even for a multi-layer ground. This could reduce the computation time significantly, especially when simulating a large borefield.

12/01445 Energy analysis of different types of buildings in Gonen geothermal district heating system

Aslan, A. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2726–2734.

Turkey is one of the top five countries for geothermal direct applications. However, in the space heating applications, a considerable amount of geothermal energy is wasted through the low thermal quality building envelopes. In the present study, the residential buildings in Gonen geothermal district heating system (GDHS) have been investigated to analyse their energy performance. The optimum insulation thicknesses of the building components, energy savings and payback periods were calculated for the four different insulation materials applied commonly on the building components. The optimization was based on the life-cycle cost analysis and the calculations were also extended to include coal and natural gas considering their wide usage for heating in the rest of the buildings in Gonen. The results proved that depending on the type of the energy and the insulation material optimum insulation thickness of the external walls, ceilings and floors varied between 2.2–12.2, 5.5–13.3 and 3.6–7.6 cm, respectively. In case of using optimum insulation thicknesses for all Gonen GDHS buildings the highest annual savings and the shortest payback periods for external walls, ceilings and floors were calculated as US$1,926,454, US$1,455,785 and US$520,248; 1.83, 1.23, and 1.44 years, respectively.

12/01446 Experience on the application of a ground source heat pump system in an archives building

Zhai, X. Q. and Yang, Y. *Energy and Buildings*, 2011, 43, (11), 3263–3270.

A ground source heat pump (GSHP) system was designed and constructed in Minhang archives of Shanghai. As a demonstration project, it is the first archives to use a GSHP system in China. The system consists of two heat pumps with the rated cooling capacity of 500 kW for each and 280 boreholes with 80 m in depth. In the cooling mode, the heat extraction from the condenser of the heat pump was divided: part of it was rejected to the soil while the rest was used to reheat the air in air handling units. The GSHP system has continuously run for nearly two years. It was shown that the indoor thermal environment met the 'Archives Design Code' issued by China national archives. Compared with an air source heat pump system which is widely used in archives buildings, the operating cost of the GSHP system is reduced by 55.8% and the payback time is about two years. Owing to its great potential in energy conservation, such kind of GSHP system is testified to be applicable to the air-conditioning systems of the archives buildings. Besides, the applications of GSHP systems corresponding to different climatic zones of China were analysed.

12/01447 Experimental and numerical analysis of an earth–air heat exchanger

Vaz, J. *et al. Energy and Buildings*, 2011, 43, (9), 2476–2482.

The need to develop new technologies that allow the use of sustainable alternative sources of energy is increasingly evident. Thus, this work presents an experimental and numerical study of earth–air heat exchangers, which are used to reduce consumption of conventional energy for heating and cooling of built environments through the use of thermal energy contained in the soil. The experiment was conducted in southern Brazil in the city of Viamão, and its results were used to validate the computational modelling of heat exchangers. In the present work, the variation of air temperature inside the ducts, to an annual cycle, was investigated. The numerical solution of the conservation equations of the problem is performed with a commercial code (FLUENT) which is based on the finite volume method (FVM). Turbulence is tackled with the Reynolds stress model (RSM). The transient temperature fields predicted numerically were compared with the experimental ones, the highest difference found was lower than 15%. The results showed the validity and effectiveness of the employed computational model, enabling its use for future researches and projects developments about earth–air heat exchangers.

12/01448 Gas and water geochemistry of geothermal systems in Dominica, Lesser Antilles island arc

Joseph, E. P. *et al. Journal of Volcanology and Geothermal Research*, 2011, 206, (1–2), 1–4.

Four of the nine potentially active volcanoes on the island of Dominica in the Lesser Antilles volcanic island arc have associated active volcanic–hydrothermal systems. Between 2000 and 2006 the gas and thermal waters from these systems were investigated to geochemically characterize the fluids, gain insight into the temperature and equilibrium state of the underlying reservoirs, and evaluate the feasibility of monitoring geothermal features as a volcano surveillance tool in Dominica. The geothermal gases are typical of those found in arc-type settings, with N_2 excess and low amounts of He and Ar. The dry gas is dominated by CO_2 (ranging from 492 to 993 mmol/mol), and has a hydrothermal signature with hydrogen sulfide as the main sulfurous gas. The waters are predominantly acid-sulfate ($SO_4 = 100$–4200 mg/L, $pH \leq 4$), and likely formed as a result of dilution of acidic gases in near surface oxygenated groundwater. Enrichment in both $\delta^{18}O$ and δD with respect to the global meteoric water line (GMWL) confirms that the waters are of primarily meteoric origin, but have been affected by evaporation processes. Quartz geothermometers gave equilibrium temperatures of 83 °C–203 °C. These temperatures contrast with the higher equilibrium temperature ranges (170 °C–350 °C) obtained for the gases using the $H_2/Ar^*–CH_4/CO_2$ gas ratios plot, suggesting that the quartz geothermometers are affected by non-attainment of equilibrium. This may be a result of precipitation of the dissolved silica and/or dilution by relatively cold shallow aquifers of the thermal fluids. Generally, no significant variations in fluid gas chemistry of the hydrothermal systems were observed during the study period, and the authors propose that there were no changes in the state of volcanic activity in this period. One exception to this occurred in a feature known as the Boiling Lake, which underwent a month-long period of significant compositional, temperature and water level fluctuations ascribed to a drastic decrease of hydrothermal input related to a perturbation in the lake (probably seismically induced). This geochemical study is part of an on-going monitoring programme of Dominica geothermal systems, aimed at establishing long-term geochemical observations for the purpose of volcano monitoring.

12/01449 Modeling and performance evaluation of shallow ground water heat pumps in Beijing plain, China

Liang, J. *et al. Energy and Buildings*, 2011, 43, (11), 3131–3138.

The use of groundwater for cooling and heating purposes is of interest from both the economical and the ecological perspective. The groundwater heat pump (GWHP) system utilizes groundwater as alternative renewable and clean energy source for space heating and/or cooling, withdraws water from a production well, passes it through a heat exchanger and discharges the water into an injection well. By utilizing the relatively stable temperature of groundwater, GWHP system can achieve a higher coefficient of performance. Due to the utilization of groundwater stored in the aquifer, the assessment of the hydraulic capacity of the aquifer based on numerical groundwater models is always needed for the optimum design and the efficient performance of GWHP. In this paper, numerical methods of underground heat-water transfer, energy balance method and thermal storage method were presented to calculate the capacity of unit area of shallow groundwater aquifer. The model results indicate that the numerical method, which is based on performance efficiency of GWHP, represents the behaviour of groundwater pumping/recharging processes, and serves better than energy balance method and thermal storage method, in addition it has been proven itself that this method has the advantages of energy saving and environmental protection. The calculated capacity is positively related to aquifer thickness. It is found that it is easy for ground water recharge in alluvial and pluvial fan located at the piedmont, while the calculated capacity is relatively smaller compared with that of south-east plain where it is not easy for groundwater recharge.

12/01450 Parametric study on the performance of a direct-expansion geothermal heat pump using carbon dioxide

Austin, B. T. and Sumathy, K. *Applied Thermal Engineering*, 2011, 31, (17–18), 3774–3782.

A numerical model has been developed to analyse the steady state performance of a direct-expansion geothermal heat pump using carbon dioxide in a transcritical cycle. The system consists of a compressor, counter-flow gas cooler/water heater, expansion device and the ground-coupled evaporator coils. The simulation results are found to be in good agreement with the results available in the literature. To analyse the performance characteristics of carbon dioxide in the ground-coupled evaporator, the parametric study focused on evaporator parameters including coil length, number of ground circuits and mean evaporation temperature. Also investigated is the relationship between gas cooler and evaporator sizing. Results indicate that there exists an optimum number of ground circuits which results in higher heating capacity and coefficient of performance. Performance can be further improved by optimizing the mean evaporation temperature with the surrounding soil temperature. With optimization, the system under study could achieve a coefficient of performance of 2.58, representing an 18% improvement compared to the baseline system.

12/01451 Performance and control of domestic ground-source heat pumps in retrofit installations

Boait, P. J. *et al. Energy and Buildings*, 2011, 43, (8), 1968–1976.

Heat pumps are an essential technology for decarbonization of domestic heating in the UK. This paper reports on the performance in use of a group of ground-source heat pumps, and in common with other UK studies finds that the seasonal performance is not as good as that reported in trials from continental Europe and that the system controls are unsatisfactory. Control improvements are investigated via a model of the dwelling and heat pump as a combined system, from which the thermal time constant of the building is identified as a critical factor that needs to be considered in retrofit projects incorporating heat pumps. The validity of the conventional practice (and advice from installers to users) of allowing heat pumps to run continuously is tested and bounded. Techniques for improving control are outlined and reasons for the poorer performance in the UK examined with the conclusion that heat pumps need to be better matched in capacity and control to the size and thermal characteristics of UK dwellings. Implementation of these findings by heat pump manufacturers and installers could promote a more rapid transition to renewable heat both in the UK and internationally wherever similar housing stocks and climates exist.

12/01452 Performance evaluations of a geothermal power plant

Coskun, C. *et al. Applied Thermal Engineering*, 2011, 31, (17–18), 4074–4082.

Thermodynamic analysis of an operational 7.5 MWe binary geothermal power plant in Tuzla, Turkey is performed, through energy and exergy, using actual plant data to assess its energetic and exergetic performances. Eight performance-related parameters, namely total exergy destruction ratio, component exergy destruction ratio, dimensionless exergy destruction, energetic renewability ratio, exergetic renewability ratio, energetic reinjection ratio, exergetic reinjection ratio and improvement potential are investigated. Energy and exergy losses/destructions for the plant and its units are determined and illustrated using energy and exergy flow diagrams. The largest energy and exergy losses occur in brine reinjection unit. The variation of the plant energy efficiency is found between 6% and 12%. Exergy efficiency values change between 35 and 49%. The annual average energy and exergy efficiencies are found as 9.47% and 45.2%, respectively.

12/01453 Production capacity estimation by reservoir numerical simulation of northwest (NW) Sabalan geothermal field, Iran

Noorollahi, Y. and Itoi, R. *Energy*, 2011, 36, (7), 4552–4569.

A three dimensional numerical model of the north-west Sabalan geothermal system was developed on the basis of the designed conceptual model from available field data. A numerical model of the reservoir was expressed with a grid system of a rectangular prism of $12\,\text{km} \times 8\,\text{km}$ with 4.6 km height, giving a total area of $96\,\text{km}^2$. The model has 14 horizontal layers ranging in thickness between 100 m to 1000 m extending from a maximum of 3600 to −1000 m a.s.l. Fifteen rock types were used in the model to assign different horizontal permeabilities from 5.0×10^{-18} to $4.0 \times 10^{-13}\,\text{m}^2$ based on the conceptual model. Natural state modelling of the reservoir was performed, and the results indicated good agreements with measured temperature and pressure in wells. Numerical simulations were conducted for predicting reservoir performances by allocating production and reinjection wells at specified locations. Three different exploitation scenarios were examined for sustainability of reservoir for the next 30 years. Effects of reinjection location and required number of makeup wells to maintain the specified fluid production were evaluated. The results showed that reinjecting at site B, immediate adjacent to production zone, is most effective for pressure maintenance of the system. On the base of existing data and assumptions the reservoir can sustain producing fluid equivalent to $50\,\text{MW}_\text{e}$ of electricity for more than 30 years. The reservoir can produce the maximum amount of fluids equivalent to $90–100\,\text{MW}_\text{e}$ for only 5 years, but the production capacity decreases to $50\,\text{MW}_\text{e}$ after 20 years of operation because of pressure and enthalpy drop. The reservoir can sustain $50\,\text{MW}_\text{e}$ over 100 years that can be defined as a sustainable production level of the field.

12/01454 Surface heat flow and CO_2 emissions within the Ohaaki hydrothermal field, Taupo volcanic zone, New Zealand

Rissmann, C. *et al. Applied Geochemistry*, 2012, 27, (1), 223–239.

Carbon dioxide emissions and heat flow have been determined from the Ohaaki hydrothermal field, Taupo volcanic zone (TVZ), New Zealand following 20 a of production ($116\,\text{MW}_\text{e}$). Soil CO_2 degassing was quantified with 2663 CO_2 flux measurements using the accumulation chamber method, and 2563 soil temperatures were measured and converted to equivalent heat flow ($\text{W}\,\text{m}^{-2}$) using published soil temperature heat flow functions. Both CO_2 flux and heat flow were analysed statistically and then modelled using 500 sequential Gaussian simulations. Forty subsoil CO_2 gas samples were also analysed for stable C isotopes. Following 20 years of production, current CO_2 emissions equated to 111 ± 6.7 T/d. Observed heat flow was 70 ± 6.4 MW, compared with a pre-production value of 122 MW. This 52 MW reduction in surface heat flow is due to production-induced drying up of all alkali–Cl outflows (61.5 MW) and steam-heated pools (8.6 MW) within the Ohaaki West thermal area (OHW). The drying up of all alkali–Cl outflows at Ohaaki means that the soil zone is now the major natural pathway of heat release from the high-temperature reservoir. On the other hand, a net gain in thermal ground heat flow of 18 MW (from 25 MW to 43.3 ± 5 MW) at OHW is associated with permeability increases resulting from surface unit fracturing by production-induced ground subsidence. The Ohaaki East (OHE) thermal area showed no change in distribution of shallow and deep soil temperature contours despite 20 a of production, with an observed heat flow of 26.7 ± 3 MW and a CO_2 emission rate of 39 ± 3 T/d. The negligible change in the thermal status of the OHE thermal area is attributed to the low permeability of the reservoir beneath this area, which has limited production (mass extraction) and sheltered the area from the pressure decline within the main reservoir. Chemistry suggests that although alkali–Cl outflows once contributed significantly to the natural surface heat flow ($\sim$50%) they contributed little ($<$1%) to pre-production CO_2 emissions due to the loss of $>$99% of the original CO_2 content due to depressurization and boiling as the fluids ascended to the surface. Consequently, the soil has persisted as the major (99%) pathway of CO_2 release to the atmosphere from the high temperature reservoir at Ohaaki. The CO_2 flux and heat flow surveys indicate that despite 20 years of production the variability in location, spatial extent and magnitude of CO_2 flux remains consistent with established geochemical and geophysical models of the Ohaaki Field. At both OHW and OHE carbon isotopic analyses of soil gas indicate a two-stage fractionation process for moderate-flux ($>60\,\text{g}\,\text{m}^{-2}\text{d}^{-1}$) sites; boiling during fluid ascent within the underlying reservoir and isotopic enrichment as CO_2 diffuses through porous media of the soil zone. For high-flux sites ($>300\,\text{g}\,\text{m}^{-2}\text{d}^{-1}$), the $\delta^{13}CO_2$ signature (-7.4 ± 0.3 OHW and -6.5 ± 0.6 OHE) is unaffected by near-surface (soil zone) fractionation processes and reflects the composition of the boiled magmatic CO_2 source for each respective upflow. Flux thresholds of $<30\,\text{g}\,\text{m}^{-2}\text{d}^{-1}$ for purely diffusive gas transport, between 30 and $300\,\text{g}\,\text{m}^{-2}\text{d}^{-1}$ for combined diffusive–advective transport, and $\geq 300\,\text{g}\,\text{m}^{-2}\text{d}^{-1}$ for purely advective gas transport at Ohaaki were assigned. $\delta^{13}CO_2$ values and cumulative probability plots of CO_2 flux data both identified a threshold of $\sim 15\,\text{g}\,\text{m}^{-2}\text{d}^{-1}$ by which background (atmospheric and soil respired) CO_2 may be differentiated from hydrothermal CO_2.

12/01455 3-D imaging of the upper crust beneath the Denizli geothermal region by local earthquake tomography, western Turkey

Kaypak, B. and Gökkaya, G. *Journal of Volcanology and Geothermal Research*, 2012, 211–212, 47–60.

The Denizli basin and its surroundings are one of the regions that have high seismic activity and rich geothermal fields in western Anatolia. In the first half of year 2000, an increasing seismic activity was observed around the Denizli basin without a large mainshock occurrence. A temporary seismic network consisting of 28 stations were deployed to observe the seismic activity in the region by the Scientific and Technological Research Council of Turkey-Marmara Research Center-Earth and Marine Science Institute. In this study, one- and three-dimensional (3-D) V_P and V_P/V_S structures of the Denizli basin have been determined by using the travel times of the 635 recorded earthquake data. First, a one-dimensional inversion schema was performed to stabilize initial velocity model and to have more reliable hypocentral locations. Then, an iterative and simultaneous three-dimensional inversion procedure was carried out to obtain 3-D high-resolution seismic velocity models. Furthermore to assess the solution quality of the inversion, the authors conducted a series of resolution tests. It was concluded that high-resolution 3-D V_P and V_P/V_S seismic velocity models for the upper 20 km of the crust beneath the Denizli basin and surroundings and interpreted the results in the context of known geologic and tectonic units. The resulting 3-D V_P models define the geometry of the basin, sediment thickness, and intrusive magmatic bodies as well as regions of anomalous velocity. The V_P/V_S models help to constrain the location and geometry of the faults, zones of weakness, and gas or fluid saturated formations with high pore pressure zones. All tomographic results show that there is a strong correlation between local seismicity and the high V_P and V_P/V_S anomalies. Consequently, this relationship indicates that the reason of the high seismicity in the Denizli basin depends on activity of hydrothermal system as well as tectonic regime.

Solar energy

12/01456 A critical review of photovoltaic–thermal solar collectors for air heating

Kumar, R. and Rosen, M. A. *Applied Energy*, 2011, 88, (11), 3603–3614.

Integrated photovoltaic–thermal solar collectors have become of great interest in the solar thermal and photovoltaic (PV) research communities. Solar thermal systems and solar PV systems have each advanced markedly, and combining the two technologies provides the opportunity for increased efficiency and expanded utilization of solar energy. In this article, the authors critically review photovoltaic–thermal solar collectors for air heating. Included is a review of photovoltaic thermal technology and recent advances, particularly as applied to air heaters. It is determined that the photovoltaic–thermal (PV/T) air heater is or may in the future be practicable for preheating air for many applications, including space heating and drying, and that integrated PV/T collectors deliver more useful energy per unit collector area than separate PV and thermal systems. Although PV/T collectors are promising, it is evident that further research is required to improve efficiency, reduce costs and resolve several technical design issues related to the collectors.

12/01457 An evaluation of the installation of solar photovoltaic in residential houses in Malaysia: past, present, and future

Muhammad-Sukki, F. *et al. Energy Policy*, 2011, 39, (12), 7975–7987.

This paper examines solar energy development in Malaysia, particularly in relation to the installation of solar photovoltaic (PV) in residential houses. It analyses the past activities related to solar energy in Malaysia, in terms of research and development, the implementations used as well as the national policies for the past 20 years which have pushed the installation of PV in the country. The feed-in tariff (FiT) scheme is discussed, showing comparative cost-benefit analysis between the PV installation in houses in the UK and Malaysia, and with other investment schemes available in Malaysia. To investigate the awareness of renewable energy policies and incentives, a preliminary survey of the public opinion in Malaysia has been carried out, and an evaluation of public willingness to invest in the FiT scheme by installing the PV on their houses is presented. The cost-benefit analysis shows that the proposed FiT programme is capable of generating good return on investment as compared to the one in the UK, but the return is lower than other investment tools. The survey suggests that most Malaysians are unaware of the government's incentives and policies towards renewable energies, and are not willing to invest in the FiT scheme.

12/01458 An urban solar flux island: measurements from London

Ryder, C. L. and Toumi, R. *Atmospheric Environment*, 2011, 45, (20), 3414–3423.

Solar irradiance measurements from a new high density urban network in London are presented. Annual averages demonstrate that central London receives $30 \pm 10\,\mathrm{W\,m^{-2}}$ less solar irradiance than outer London at midday, equivalent to $9 \pm 3\%$ less than the London average. Particulate matter and AERONET measurements combined with radiative transfer modelling suggest that the direct aerosol radiative effect could explain 33–40% of the inner London deficit and a further 27–50% could be explained by increased cloud optical depth due to the aerosol indirect effect. These results have implications for solar power generation and urban energy balance models. A new technique using 'Langley flux gradients' to infer aerosol column concentrations over clear periods of 3 h has been developed and applied to three case studies. Comparisons with particulate matter measurements across London have been performed and demonstrate that the solar irradiance measurement network is able to detect aerosol distribution across London and transport of a pollution plume out of London.

12/01459 Application of a compact sorption generator to solar refrigeration: case study of Dakar (Senegal)

Metcalf, S. J. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2197–2204.

The feasibility of applying a low cost plate heat exchanger solid sorption reactor to solar powered refrigeration is investigated by using a validated reactor model. The proposed system is targeted at ice-making in developing countries for food preservation. The adsorption refrigeration machine modelled employs the active carbon-ammonia working pair in both two-bed and four-bed regenerative systems. Driving heat is provided from standard flat plate and evacuated tube solar collectors. The capital cost of a one-off machine with four regenerative beds which could produce up to 1000 kg of ice per day in Dakar (Senegal) is estimated at €68,000.

12/01460 Application of transparent dye-sensitized solar cells to building integrated photovoltaic systems

Yoon, S. *et al. Building and Environment*, 2011, 46, (10), 1899–1904.

Dye-sensitized solar cell (DSSC) is one of the most promising photovoltaic systems for building integration (BIPV). DSSC can be transparent with various degrees of transparency, which makes it suitable for window application in buildings. In this study, the relationship between the transparency, the efficiency of DSSC and the overall energy efficiency of a building when DSSC is applied as window system is investigated. It is shown that while the efficiency of less transparent DSSC is generally higher due to higher short circuit current density (J_{sc}) from the thick electrode, it does not necessarily maximize the overall energy efficiency of a building. This is because lighting conditions of the building varies with the transparency of the window. The optimum condition should be carefully considered with the transparency of window as computationally simulated in terms of energy generation and consumption. It is also found that different orientations of window in the building affect the optimum conditions of DSSC.

12/01461 Application potential of solar air-conditioning systems for displacement ventilation

Fong, K. F. *et al. Energy and Buildings*, 2011, 43, (9), 2068–2076.

Solar air-conditioning can have higher application potential for buildings through the strategy of high-temperature cooling. In recent years, displacement ventilation (DV), which makes use of the indoor rising plumes from the internal heat gains, provides a more effective supply air option than the traditional mixing ventilation (MV) in terms of both thermal comfort and indoor air quality. As it is possible to raise the supply air temperature to 19 °C for DV, it would enhance the competitive edge of the solar air-conditioning against the conventional vapour compression refrigeration. Through dynamic simulation, a solar-desiccant-cooling displacement ventilation system (SDC_DV) was developed for full-fresh-air provision, while a solar-hybrid-desiccant-cooling displacement ventilation system (SHDC_DV) for return air arrangement. The latter was further hybridized with absorption chiller (AB) to become $\mathrm{SHDC_{AB}}$_DV, or adsorption chiller (AD) to be $\mathrm{SHDC_{AD}}$_DV, in order to be wholly energized by the solar thermal gain. Benchmarked with the conventional system using MV, the SDC_DV had 43.3% saving in year-round primary energy consumption for a typical office in the subtropical climate; the $\mathrm{SHDC_{AB}}$_DV had 49.5% saving, and the $\mathrm{SHDC_{AD}}$_DV had 18.3% saving. Compared with their MV counterparts, the SDC_DV, the $\mathrm{SHDC_{AB}}$_DV and the $\mathrm{SHDC_{AD}}$_DV could have 42.4%, 21.9% and 30.3% saving respectively.

12/01462 Appropriate storage for high-penetration grid-connected photovoltaic plants

Solomon, A. A. *et al. Energy Policy*, 2012, 40, 335–344.

This paper addresses the dual questions: what is the appropriate storage size and its related properties for matching very large photovoltaic plants to the grid; and what are the available technologies for achieving this end? For this purpose a 'usefulness index' is defined, which, for any grid flexibility, leads to a PV-storage combination that allows high grid-penetration without storage being wastefully large. The paper then examines the sensitivity of this 'appropriate storage size' to variations in the assumptions. The specific case of the Israeli electricity grid is employed for numerical discussion, but the formalism should be useful for wider application. In particular, the 'appropriate storage size' deduced in this manner is argued to be a valuable point of departure for optimizations of a more sophisticated nature. Regarding available storage technologies, none is found to have all of the required properties for massive PV-grid penetration, but hybrid combinations should be capable of achieving this end.

12/01463 Assessment of the thermal and visual efficiency of solar shades

David, M. *et al. Building and Environment*, 2011, 46, (7), 1489–1496.

Solar shades are efficient architectural elements in order to reduce the thermal loads inside buildings. In one way, they can reduce significantly the energy needs of cooling systems. But in other way, they can decrease the visual comfort and increase the energy consumption of artificial lighting. Actually, the sizing of shading devices is mainly a thermal optimization process. The efficacy of solar shades must be assess taking into account both thermal and visual point of view. In this paper simple indices were proposed to compare the thermal and visual efficacy of different types of solar shadings in non-residential buildings. These indices can be derived from the results of numerical simulations that include thermal and daylighting analysis such as the EnergyPlus software. A typical office is studied in order to assess the efficacy of different types of solar protections. The use of the proposed indices made obvious the choice and the sizing of the most efficient solar shade for the case study.

12/01464 Bed agglomeration characteristics of palm shell and corncob combustion in fluidized bed

Chaivatamaset, P. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2916–2927.

Bed particle agglomeration was studied experimentally in an atmospheric laboratory scale fluidized bed combustor using quartz sand as bed material. Palm shell and corncob were tested. The objectives of the study were (i) to describe the contributions of the biomass ash properties and the operating conditions on the bed agglomeration tendency in term of the bed defluidization time (t_{def}) and the extent of potassium accumulation in the bed (K/Bed) and (ii) to further elucidate the ash inorganic behaviours and the governing bed agglomeration mechanisms. Defluidization caused by the bed agglomeration was experienced in all experiments during combustion of these biomasses, as a consequence of the presence of potassium in biomass. The experimental results indicated that biomass ash characteristics were the significant influence on the bed agglomeration. The increasing bed temperature, bed particle size and static bed height and the decreasing fluidizing air velocity enhanced the bed agglomeration tendency. The SEM/EDS analyses on the agglomerates confirmed that the agglomeration was attributed to the formation of potassium silicate liquid enriched on the surface of quartz sand particles in conjunction with the high surface temperature of the burning biomass char particles. Thermodynamic examination based on the phase diagram analysis confirmed that the molten phase formation was responsible for the agglomeration. In this study, the high molten ash fraction resulting from the high potassium content in biomass promoted the agglomeration and thus defluidization.

12/01465 Characteristics of heat dissipation from photovoltaic cells on the bottom wall of a horizontal cabinet to ambient natural convective air stream

Tsay, Y. L. *et al. Energy*, 2011, 36, (7), 3959–3967.

This study proposes a model to investigate the behaviours of natural convective cooling of photovoltaic cells mounted discretely on the bottom wall of a horizontal cabinet. The effects of Rayleigh number (Ra), dimensionless length of cabinet (C_x), ratio of cabinet wall to air thermal conductivities (K_{ef}), number of photovoltaic cells (N), emissivity of metal wall (ε_e), and emissivity of glass lens (ε_g) are explored. Furthermore, the importance of thermal interaction between air streams inside and outside the cabinet through conducting wall are examined. The numerical computation domain covers the cabinet and surrounding area, so that the temperature and velocity fields of the combined regions are solved simultaneously. Results show that temperature differences among the photovoltaic cells can be up to 28% for all the investigated cases when $10^6 \leq Ra \leq 10^8$, $5 \leq C_x \leq 12.5$, $4 \leq N \leq 10$, $1000 \leq K_{ef} \leq 6300$, $0 \leq \varepsilon_e \leq 0.5$ and $0 \leq \varepsilon_g \leq 0.94$. The maximum difference in hot spot temperatures of photovoltaic cells is about 26% among the cases with various K_{ef}. In addition, the temperatures are rather low for the situation without consideration of thermal interaction between the air streams inside and outside the cabinet. Therefore, without the consideration of the thermal interaction would cause serious under-prediction for the hot spot temperatures of photovoltaic cells in engineering applications.

12/01466 Comparative experiment study on photovoltaic and thermal solar system under natural circulation of water

He, W. *et al. Applied Thermal Engineering*, 2011, 31, (16), 3369–3376.

The hybrid photovoltaic and thermal (PV/T) system can utilize solar energy more effectively and has a higher total efficiency compared with a traditional solar collecting system and a photovoltaic (PV) module. However, there is limited experimental data on how much energy the PV/T system can save when operating with same area of a PV plate and a solar collector simultaneously. In this paper, a comparative test rig had been set up to measure and analyse the performance of PV/T system. There were monocrystalline silicon PV/T solar collector, a traditional solar collector and a monocrystalline silicon photovoltaic plate. The PV/T collector and the traditional solar collector had the same collecting areas and solar cell covered area of the PV/T collector was the same as the area of the photovoltaic plate. The experimental results showed that the daily thermal efficiency of PV/T system was about 40%, which was about 75% of that for a traditional solar thermosiphon system, and the daily average electrical efficiency was found about 10%, which was a little lower than the photovoltaic module. But primary-energy saving efficiency of the PV/T system was much higher than that of the individual PV plate and the traditional solar collector.

12/01467 Degradation of trinitrophenol by sequential catalytic wet air oxidation and solar TiO_2 photocatalysis

Katsoni, A. *et al. Chemical Engineering Journal*, 2011, 172, (2–3), 634–640.

Catalytic wet air oxidation (CWAO) and solar TiO_2 photocatalysis were investigated as advanced oxidation processes to degrade trinitrophenol (TNP) in model aqueous solutions. An activated carbon (AC) treated with sulfuric acid of different concentrations (5, 10 and 18 M) at two different temperatures (353 and 423 K) was investigated as a metal-free CWAO catalyst, while a commercially available P25 TiO_2 powder was used as a photocatalyst. CWAO experiments were conducted at 448 K, 0.7 MPa oxygen pressure (4.7 MPa of total pressure), 1.3 g L^{-1} AC loading and 270 mg L^{-1} TNP concentration, while photocatalytic experiments were conducted at ambient temperature, 1 g L^{-1} photocatalyst loading, 500–1000 W m^{-2} irradiance provided by a solar simulator and 32–270 mg L^{-1} TNP concentration. Treatment efficiency was assessed by measuring the concentrations of TNP and nitrates, total organic carbon (TOC) and biochemical oxygen demand (BOD_5). Up to 90% TNP degradation was attained during CWAO over 120 min, from an initial concentration of 270 mg L^{-1}. For the same TNP concentration, TiO_2 photocatalysis gives only 13% conversion over the same 120 min. However, for TNP concentrations below 144 mg L^{-1}, photocatalysis can be effectively used: 100 and 80% TNP degradation obtained in 120 min of irradiation for initial TNP concentrations of 64 and 144 mg L^{-1}, respectively. In this respect, CWAO and photocatalysis were employed sequentially to treat TNP; complete TNP conversion being achieved after 120 min of CWAO followed by 60 min of photocatalysis at 1000 W m^{-2} irradiance, and this was accompanied by 82% TOC reduction, as well as an increase of BOD_5/TOC ratio from 0 to 2.28.

12/01468 Effect of aperture position and size on natural convection heat loss of a solar heat-pipe receiver

Wu, S.-Y. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2787–2796.

A new configuration of heat-pipe receiver is introduced to realize the isothermal light-heat conversion for middle- and high-temperature solar dish system. A 3-D numerical study has been performed to investigate the influence of aperture characteristics, i.e. aperture position and size on natural convection heat loss of this heat-pipe receiver accounting for air property variation with temperature. Temperature and velocity contours as well as the effects of aperture position and size on the natural convection heat loss have been well presented and discussed. It is revealed that the impact of aperture position on the natural convection heat loss is closely related to tilt angle, while the aperture size has similar effect for different tilt angles. The natural convection heat loss approximately is linearly dependent on wall temperature for different aperture positions and sizes. A new simplified Nusselt number correlation that can estimate natural convection heat loss with reasonable accuracy is proposed based on the corresponding numerical results. It is shown that the natural convection heat loss predictions by the present model show smallest deviation from the experimental results as compared to other well-known models regardless a partially or fully opened heat-pipe receiver for middle- and high-temperature solar dish system.

12/01469 Electrical and thermal performance of silicon concentrator solar cells immersed in dielectric liquids

Han, X. *et al. Applied Energy*, 2011, 88, (12), 4481–4489.

Direct liquid-immersion cooling of concentrator solar cells was proposed as a solution for receiver thermal management of concentrating photovoltaic (CPV) and hybrid concentrating photovoltaic thermal (CPV-T) systems. De-ionized (DI) water, isopropyl alcohol (IPA), ethyl acetate, and dimethyl silicon oil were selected as potential immersion liquids based on optical transmittance measurement results. Improvements to the electrical performance of silicon CPV cells were observed under a range of concentrations in the candidate dielectric liquids, arising from improved light collection and reduced cell surface recombination losses from surface adsorption of polar molecules. Three-dimensional numerical simulations with the four candidate liquids as the working fluids, exploring the thermal performance of a silicon CPV cell array in a liquid immersion prototype receiver, have been performed. Simulation results show that the direct-immersion cooling approach can maintain low and uniform cell temperature in the designed liquid immersion receiver. The fluid inlet velocity and flow mode, along with the fluid thermal properties, all have a significant influence on the cell array temperature.

12/01470 Energy and exergy analysis of solar power tower plants

Xu, C. *et al. Applied Thermal Engineering*, 2011, 31, (17–18), 3904–3913.

Establishing the renewable electricity contribution from solar thermal power systems based on energy analysis alone cannot legitimately be complete unless the exergy concept becomes a part of that analysis. This paper presents a theoretical framework for the energy analysis and exergy analysis of the solar power tower system using molten salt as the heat transfer fluid. Both the energy losses and exergy losses in each component and in the overall system are evaluated to identify the causes and locations of the thermodynamic imperfection. Several design parameters including the direct normal irradiation (DNI), the concentration ratio, and the type of power cycle are also tested to evaluate their effects on the energy and exergy performance. The results show that the maximum exergy loss occurs in the receiver system, followed by the heliostat field system, although main energy loss occurs in the power cycle system. The energy and exergy efficiencies of the receiver and the overall system can be increased by increasing the DNI and the concentration ratio, but that increment in the efficiencies varies with the values of DNI and the concentration ratio. It is also found that the overall energy and exergy efficiencies of the solar tower system can be increased to some extent by integrating advanced power cycles including reheat Rankine cycles and supercritical Rankine cycles.

12/01471 Energy management in solar thermal power plants with double thermal storage system and subdivided solar field

Rovira, A. *et al. Applied Energy*, 2011, 88, (11), 4055–4066.

In the paper, two systems for solar thermal power plants (STPPs) are devised for improving the overall performance of the plant. Each one attempts to reduce losses coming from two respective sources. The systems are simulated and compared to a reference STPP. They consists on: (a) a double thermal energy storage (DTS) with different functionalities for each storage and (b) the subdivision of the solar collector field (SSF) into specialized sectors, so that each sector is designed to meet a thermal requirement, usually through an intermediate heat exchanger. This subdivision reduces the losses in the solar field by means of a decrease of the temperature of the heat transfer fluid (HTF). Double thermal energy storage is intended for keeping the plant working at nominal level for many hours a day, including post-sunset hours. One of the storages gathers a fluid which is heated up to temperatures above the nominal one. In order to make it work, the solar field must be able to overheat the fluid at peak hours. The second storage is the classical one. The combination of both allows the manager of the plant to keep the nominal of the plant for longer periods than in the case of classical thermal energy storage. To the authors' knowledge, it is the first time that both configurations are presented and simulated for the case of parabolic through STPP with HTF technology. The results show that, if compared to the reference STPP, both configurations may raise the annual electricity generation (up to 1.7% for the DTS case and 3.9% for the SSF case).

12/01472 Energy saving in buildings by using the exhaust and ventilation air for cooling of photovoltaic panels

Shahsavar, A. *et al. Energy and Buildings*, 2011, 43, (9), 2219–2226.

A building integrated photovoltaic-thermal (BIPVT) setup has been developed for using the cooling potential of ventilation and exhaust airs in buildings for cooling the photovoltaic (PV) panels and also heating the ventilation air by heat rejection of PV panels. The setup has been tested numerically for the Kerman city located in Kerman province in the south of Iran. Results showed that, the exhaust and ventilation airs in heating ventilating air conditioning systems can be used as the cooling fluid of the PV panels and increase their efficiency. On the other hand, the heat rejection of the PV panels could provide some part of the ventilation air heating load.

12/01473 Experimental investigation on a one-rotor two-stage desiccant cooling/heating system driven by solar air collectors

Li, H. *et al. Applied Thermal Engineering*, 2011, 31, (17–18), 3677–3683.

A solar driven one-rotor two-stage desiccant cooling/heating system is experimentally investigated. It consists primarily of a 5 kW desiccant cooling system and 15 m^2 of solar air collectors. The desiccant cooling/heating system uses solar thermal energy to regenerate desiccant wheel in summer, and to produce hot air for space heating in winter. In summer, the outlet temperature of solar air collectors is about 60–100 °C. For the solar driven one-rotor two-stage desiccant cooling system, the moisture removal can reach 8–9 g/kg and supply air condition is about 22 °C and 60% RH. Experimental results indicated that the average thermal COP in cooling cycle is 0.95 in hot and humid climate conditions. The solar COP of system is about 0.45 when thermal efficiency of collector is 50%. This suggested that the system could convert more than 40% of the received solar radiant intensity to cooling power in sunny days. In addition, the effect of regeneration temperature on the system performance is studied. It was found that average of temperature difference between ambient and room can reach 13 °C for space heating in winter. Coupled with desiccant cooling system, solar air collectors can realize year-round running.

12/01474 Financial viability and eco-efficiency of the solar home systems (SHS) in Bangladesh

Chakrabarty, S. and Islam, T. *Energy*, 2011, 36, (8), 4821–4827.

To analyse financial viability as well as eco-efficiency of the solar home systems in Bangladesh six case studies are carried out in some selected villages of Chhatak county in Bangladesh where NGOs like Grameen Shakti and BRAC are delivering and servicing solar home systems. Financial viability of solar home systems is measured by comparing prior expenditure (before implementing solar home systems) for kerosene, automobile battery and other conventional sources. Eco-efficiency refers to an estimator that seeks to maximize the effectiveness of financial viability while counting their costs on the environment. The financial viability and eco-efficiency for six different cases of SHS are calculated and compared. This provides information about the relative performance of the product in six different situations. Solar electrification results a number of income generating new green employments for the rural community in Bangladesh. Although financial viability of solar home systems is sensitive to kerosene subsidy, this study reveals that solar home systems are financially more attractable when it is used for small income generating activities other than used only for lighting purposes. However, almost in all cases this technology is indispensable for improving environmental standard and eco-efficiency of the rural community.

12/01475 Guidelines for the technical assessment of harmonic, flicker and unbalance emission limits for PV-distributed generation

Hernández, J. C. *et al. Electric Power Systems Research*, 2011, 81, (7), 1247–1257.

Photovoltaic-distributed generation (PV-DG) is increasingly being embedded in distribution networks, and this is the source of a wide range of PQ problems. Consequently, the distribution network operator needs a coherent set of technical requirements for individual PV-DG units as well as for system EMC management in order to ensure PQ. Currently, the EMC poses the following challenges for PV-DG units connected to the distribution network: (a) PV-DG individual equipment should limit its emissions according to particular product-family standards with specific tests under a given set of conditions; (b) PV-DG units should be incorporated as a 'user', and its emissions managed according to existing allocation practices. This paper gives an overview of the current state of knowledge within the context of IEC regulations, particularly in regards to harmonics, flicker, and voltage unbalance. It thus focuses on the assessment of emission levels for (large) PV-DG units connected to LV and MV networks, as reflected in IEC publications. Such evaluation procedures are all based on a common philosophy. When no standard values are available, optimal values for certain variables (e.g. planning levels, transfer coefficients, and others), are proposed. A brief description is also provided of methods for measuring disturbing emissions and the PQ indices that characterize such emissions. Finally, recommendations are given regarding existing product family standards with a view to creating a set of PV-DG equipment standards.

12/01476 Heat extraction methods from salinity-gradient solar ponds and introduction of a novel system of heat extraction for improved efficiency

Leblanc, J. *et al. Solar Energy*, 2011, 85, (12), 3103–3142.

Heat has generally been successfully extracted from the lower convective zone (LCZ) of solar ponds by two main methods. In the first, hot brine from the LCZ is circulated through an external heat exchanger, as tested and demonstrated in El Paso and elsewhere. In the second method, a heat transfer fluid circulates in a closed cycle through an in-pond heat exchanger, as used in the Pyramid Hill solar pond, in Victoria, Australia. Based on the experiences at the El Paso and Pyramid Hill solar ponds, the technical specifications, material selection, stability control, clarity maintenance, salt management and operating strategies are presented. A novel method of extracting heat from a solar pond is to draw the heat from the gradient layer. This method is analysed theoretically and results of an experimental investigation at Bundoora East, RMIT, are presented. An in-pond heat exchanger made of polyethylene pipe has been used to extract heat for over 2 months. Results indicate that heat extraction from the gradient layer increases the overall energy efficiency of the solar pond by up to 55%, compared with conventional method of heat extraction solely from the LCZ. The experimental results are compared with the theoretical analysis. A close agreement has been found. From this small-scale experimental study, convection currents were found to be localized only and the density profiles were unaffected. An experimental study using an external heat exchanger for brine extraction and re-injection at different levels within the gradient layer still needs to be conducted to determine the effect of the heat extraction from the non-convective zone on the stability of the salinity gradient (both vertically and horizontally) and an economic analysis needs to be conducted to determine the economic gains from increased thermal efficiency.

12/01477 Incorporation of plasma-functionalized carbon nanocapsules into a nanocrystalline TiO_2 photoanode for use in dye-sensitized solar cells

Chan, Y.-F. *et al. Carbon*, 2011, 49, (14), 4898–4910.

Dye-sensitized solar cells (DSSCs) were fabricated using TiO_2 nanoparticles incorporating different amounts of plasma functionalized carbon nanocapsules (CNCs) as the photoanode. The functionalization was obtained by grafting maleic anhydride (MA) onto the walls of CNCs immediately after the *in situ* argon plasma treatment. Nanocrystalline semiconductor film electrodes were prepared by sintering TiO_2 with added MA-CNCs on a conducting glass substrate. Capacitance measurements obtained from electrochemical impedance spectroscopy (EIS) analysis in an aqueous electrolyte are fitted using the Mott–Schottky relationship and demonstrate the variation of flatband potential (V_{fb}) for the composite with MA-CNC content. The potential chronoamperometric and cyclic voltammetric data supports the argument that the increased V_{fb} minimizes the defect state for trapping/detrapping of electrons within the MA-CNC/TiO_2. As a result of higher film capacitance and electron accumulation, the MA-CNC/TiO_2 shows increased conversion efficiency and photocurrent density when used as the photoanode in DSSCs. EIS measurement further demonstrates that charge recombination at the interface of MA-CNC/TiO_2 and electrolyte is suppressed with increasing electron lifetime and is in good agreement with the photovoltaic performance. The amount of MA-CNCs added, however needs to be optimized due to the unavoidable issue of aggregation.

12/01478 On effect of wind speed on passive solar still performance based on inner/outer surface temperatures of the glass cover

El-Sebaii, A. A. *Energy*, 2011, 36, (8), 4943–4949.

The thermal performance of a passive single basin solar still was investigated by computer simulation using the climatic conditions of Jeddah (latitude 21°42′N, longitude 39°11′E), Saudi Arabia under the two conditions: (a) the temperatures of the inner T_{gi} and outer T_{go} surfaces of the still cover are equal and (b) the temperatures of the inner T_{gi} and outer T_{go} surfaces of the still cover are not equal. Effect of wind speed V on the daily productivity P_d of the still for these conditions was studied. It was indicated that for the condition $T_{gi} = T_{go}$, there is a critical mass (depth) of basin water beyond which P_d increases as V increases until a typical velocity V_t. For basin water masses less than the critical mass, P_d was found to decrease with increasing V until V_t. After V_t, the change in P_d becomes insignificant. When $T_{gi} \neq T_{go}$, P_d was found to be less dependent on wind speed V for all investigated values of mass of basin water m_w in the range $0 < m_w \geq 100$ kg. The rate of heat transfer by forced convection due to wind should be estimated on the basis of the temperature of the upper surface of the still cover.

12/01479 Overcoming obstacles against effective solar lighting interventions in south Asia

Wong, S. *Energy Policy*, 2012, 40, 110–120.

Basing on the devised World Bank's 'design principles' for effective renewable energy projects in developing countries and an in-depth analysis of two solar lighting projects in Bangladesh and India, this paper explores three key obstacles that constrain poor people from obtaining solar lighting: financial exclusion, weak governance, and passive NGO and customer participation. The low take-up rate has a social and psychological impact. This paper recommends creating easy access to credit, establishing a robust complaint system, and developing strategic partnership to overcome the obstacles.

12/01480 Synthesis of nitrogen-doped carbon thin films and their applications in solar cells

Cui, T. *et al. Carbon*, 2011, 49, (15), 5022–5028.

N-doped carbon thin films (N-CFMs) on copper foils are synthesized by using acetonitrile (CH_3CN) as liquid carbon and nitrogen precursors in a chemical vapour deposition system. Effect of acetonitrile feeding amount on the optical transmittance and electrical conductivity of N-CFMs are investigated. It is found that both the transmittance (from ~41% to ~75%) and sheet resistance (from ~700 Ω/sq to ~2000 Ω/sq) increases with the decrease of acetonitrile feeding amount (from 200 μL to 10 μL). Schottky junction solar cells based on n-type silicon and as-synthesized N-CFMs demonstrate power conversion efficiencies of up to ~1.55%, showing their potential applications in photovoltaic areas.

12/01481 The potential role of concentrated solar power (CSP) in Africa and Europe – a dynamic assessment of technology development, cost development and life cycle inventories until 2050

Viebahn, P. *et al. Energy Policy*, 2011, 39, (8), 4420–4430.

Concentrated solar power (CSP) plants are one of several renewable energy technologies with significant potential to meet a part of future energy demand. An integrated technology assessment shows that CSP plants could play a promising role in Africa and Europe, helping to reach ambitious climate protection goals. Based on the analysis of driving forces and barriers, at first three future envisaged technology scenarios are developed. Depending on the underlying assumptions, an installed capacity of 120 $\mathrm{GW_{el}}$, 405 $\mathrm{GW_{el}}$ or even 1,000 $\mathrm{GW_{el}}$ could be reached globally in 2050. In the latter case, CSP would then meet 13–15% of global electricity demand. Depending on these scenarios, cost reduction curves for North Africa and Europe are derived. The cost assessment conducted for two virtual sites in Algeria and in Spain shows a long-term reduction of electricity generating costs to figures between 4 and 6 $\mathrm{ct/kWh_{el}}$ in 2050. The paper concludes with an ecological analysis based on life cycle assessment. Although the greenhouse gas emissions of current (solar only operated) CSP systems show a good performance (31 g CO_2-equivalents/$\mathrm{kWh_{el}}$) compared with advanced fossil-fired systems (130–900 CO_2-eq./$\mathrm{kWh_{el}}$), they could further be reduced to 18 g CO_2-eq./$\mathrm{kWh_{el}}$ in 2050, including transmission from North Africa to Europe.

12/01482 The role of the quinonine and pyridine added to catechol to improve the efficiency of dye sensitized solar cell: an ab initio study

Mai, A. T. *et al. Energy Conversion and Management*, 2012, 53, (1), 68–74.

Recently, dye-sensitized solar cell (DSSC) has attracted the attention of research worldwide and become a low-cost solar cell with highest efficiencies exceeding 11%. To date, many works have been devoted to improve the efficiencies of DSSC by both materials and electrical approach. The time-dependent (TD) density functional theory (DFT)-based procedure made it possible to get insights into the geometrical and electronic structures of the dyes and to unravel the structural modifications optimizing the properties of catechol-based DSSC. The authors try to explain the electron injection pathways of catechol (Cat), (pyridin-4-yl)vinyl and (quinolinyl)vinyl to catechol (known as Cat-v-P and Cat-v-Q) bound to TiO_2 cluster and explain the role of quinonine and pyridine, as electron donor, to catechol which contribute to increase the quality factor of the cell.

12/01483 Theoretical and experimental investigation on the application of solar water heater coupled with air humidifier for regeneration of liquid desiccant

Alosaimy, A. S. and Hamed, A. M. *Energy*, 2011, 36, (7), 3992–4001.

Theoretical and experimental investigation on the application of flat plate solar water heater coupled with air humidifier for regeneration of liquid desiccant has been presented in this work. The heated water from the storage tank of the solar heating system is circulated in a finned tube air heater. Hot air from the air heater is blown through a packing of a honeycomb type for the purpose of regeneration of calcium chloride ($CaCl_2$) solution. An experimental system has been designed and installed for this purpose. The system comprises a solar water heater with a storage tank connected to an air/water heat exchanger. Hot air from the heat exchanger is blown to the air humidifier, which functions in this study as a regenerator. Calcium chloride solution is applied as the working desiccant in this study. Solution concentration is determined at the end of regeneration process and the mass of evaporated water is evaluated. It is observed that the heating temperature varies, at day time, in a range of about 5 °C. This limited variation in hot water temperature demonstrates the importance of the storage tank to attain a nearly steady state operation of the system. Experimental results show that solution with 30% concentration can be regenerated up to 50% using solar energy. In the theoretical part of this study, a multiple-layer artificial neural network (ANN) model has been applied to study the performance of a solar liquid-desiccant dehumidification/regeneration system when calcium chloride solution is applied as the working desiccant. The experimental results of the present study are used to construct and test the ANN model. Then the model has been utilized to describe and analyse the effect of the inlet conditions of air on the regeneration process. Good agreement between the outputs from the ANN model and the corresponding results from the experimental data has been found. The proposed model can work well as a predictive tool to complement the experiments.

12/01484 Thermal and mechanical performance of sealed, gas-filled, flat plate solar collectors

Vestlund, J. *et al. Solar Energy*, 2012, 86, (1), 13–25.

The study includes calculations for both the thermal performance and the mechanical behaviour of a gas-filled, flat plate solar collector without external gas expansion, i.e. a collector with varying gas volume and gas pressure and movement in both cover glass and absorber. Classical theories for the thermal performance are combined with a finite-element method to investigate which factors have an impact from the mechanical stress point of view. This article describes major results for collectors with copper and aluminium absorbers combined with different inert gases. It is shown that a collector may be designed which uses less material than a standard collector but achieves at least the same thermal performance, by using a thinner collector and a thinner absorber and a suitable gas filling other than air. If copper is used in absorber and tubes, a 0.15 mm thick absorber together with a tube-to-tube distance of 103 mm results in the same performance as a 0.3 mm absorber with a 144 mm tube-to-tube distance, but the former will use 25% less material. The use of copper can be further reduced if the absorber is made of aluminium and the tubes are made of copper. The factor of safety for thick (>0.5 mm) aluminium absorbers is, however, not as large as it is for copper absorbers.

Wind energy

12/01485 An investigation on the impacts of regulatory interventions on wind power expansion in generation planning

Alishahi, E. *et al. Energy Policy*, 2011, 39, (8), 4614–4623.

Large integration of intermittent wind generation in power system has necessitated the inclusion of more innovative and sophisticated approaches in power system investment planning. This paper presents a novel framework on the basis of a combination of stochastic dynamic programming (SDP) algorithm and game theory to study the impacts of different regulatory interventions to promote wind power investment in generation expansion planning. In this study, regulatory policies include feed-in-tariff (FIT) incentive, quota and tradable green certificate. The intermittent nature and uncertainties of wind power generation will cause the investors encounter risk in their investment decisions. To overcome this problem, a novel model has been derived to study the regulatory impacts on wind generation expansion planning. In approach presented here, the probabilistic nature of wind generation is modelled. The model can calculate optimal investment strategies, in which the wind power uncertainty is included. This framework is implemented on a test system to illustrate the working of the proposed approach. The result shows that FITs are the most effective policy to encourage the rapid and sustained deployment of wind power. FITs can significantly reduce the risks of investing in renewable energy technologies and thus create conditions conducive to rapid market growth.

12/01486 Assessment of electricity generation and energy cost of wind energy conversion systems in north-central Nigeria

Adaramola, M. S. *et al. Energy Conversion and Management*, 2011, 52, (12), 3363–3368.

In this study, the wind energy potential and economic analysis in selected six locations in north central part of Nigeria were investigated using wind speed data that span between 19 and 37 years measured at 10 m height. The performance of small to medium size commercial wind turbine models were examined and economic evaluation of the wind energy in the selected sites was made by using the levelized cost method. The results showed that the cost of energy production per kWh for the selected sites vary between ¢4.02 and ¢166.79. It was shown that Minna is most viable site while Bida is found to be least among the sites considered. Using three selected wind turbine models (in Minna) as case study, an increase in the escalation rate of operating and maintenance cost from 0% to 10%, lead to an increase in the unit energy cost by about 7%. It was further shown that by increasing the escalation rate of inflation from 0% to 5%, the cost of energy decreases by about 29% while the discount rate (return on investment) decreases from 11.54% to 6.23%.

12/01487 Assessment of the benefits of numerical weather predictions in wind power forecasting based on statistical methods

De Giorgi, M. G. *et al. Energy*, 2011, 36, (7), 3968–3978.

Several forecast systems based on artificial neural networks have been developed to predict power production of a wind farm located in a complex terrain, where geographical effects make wind speed predictions difficult) in different time horizons: 1, 3, 6, 12 and 24 h. In the first system, the neural network has been used only as a statistic model based on time series of wind power; later it has been integrated with numerical weather predictions, by which an interesting improvement of the performance has been reached, especially with the longer time horizons. In particular, a sensitivity analysis has been carried out in order to find those numerical weather parameters with the best impact on the forecast. Then, after the implementation of forecast systems based on a single ANN, the two best prediction systems individuated through the sensitivity analysis, have been employed in a hybrid approach, made up of three different ANNs. Besides, a prediction system based on the wavelet decomposition technique has been also carried out in order to evaluate its contribute on the forecast performance in two time horizons (1 and 24 h). The error of the different forecast systems is investigated and the statistical distributions of the error are calculated and presented.

12/01488 Building mounted wind turbines and their suitability for the urban scale – a review of methods of estimating urban wind resource

Walker, S. L. *et al. Energy and Buildings*, 2011, 43, (8), 1852–1862.

In this paper, a review is presented of academic literature regarding urban wind speeds for building mounted wind turbines. Site measurement of wind speed requires time and money that often are not available for small micro-generation projects. Research into wind speed estimation for the urban environment has shown that street canyons affect urban wind flow, that wind speed up over the roof ridge is only evident for isolated single buildings, that the wind resource 'seen' by a building mounted wind turbine is affected by positioning (height above roof ridge and position relative to the prevailing wind direction), that urban terrain roughness is high, and that adjacent buildings can cause wind shadow. This multiplicity of factors makes it difficult to generalize a wind resource estimation methodology for the urban environment. Scaling factors may prove to be a practical solution, provided the accuracy of their use is well understood.

12/01489 Comparison between ANNs and linear MCP algorithms in the long-term estimation of the cost per kW h produced by a wind turbine at a candidate site: a case study in the Canary Islands

Velázquez, S. *et al. Applied Energy*, 2011, 88, (11), 3869–3881.

In the work presented in this paper artificial neural networks (ANNs) were used to estimate the long-term wind speeds at a candidate site. The specific costs of the wind energy were subsequently determined on the basis of the knowledge of these wind speeds. The results were compared with those obtained with a linear measure–correlate–predict (MCP) method. The mean hourly wind speeds and directions recorded over a 10-year period at six weather stations located on different islands in the Canary archipelago (Spain) were used as a case study. The power-wind speed curves for five wind turbines of different rated power were also used. The mean absolute percentage error (MAPE), Pearson's correlation coefficient and the index of agreement between measured and estimated data were used to evaluate the errors made with the different metrics analysed. Amongst the conclusions that can be drawn from the study it can be stated that, in all the cases analysed, the MAPE of the specific cost of the energy obtained using ANNs was lower than that obtained with the linear MCP method that was employed. In some cases reductions in the error of up to 26.5% were achieved with the ANNs with respect to the method used for purposes of comparison. However, when the correlation coefficients between the short-term data series of the candidate and reference sites were relatively low, the MAPEs generated by all the analysed metrics were higher when the estimation models were used than when the data for the short-term period at the candidate site was taken as being representative of the long-term wind performance at that site.

12/01490 Economic feasibility and optimisation of an energy storage system for Portland wind farm (Victoria, Australia)

Hessami, M.-A. and Bowly, D. R. *Applied Energy*, 2011, 88, (8), 2755–2763.

This paper presents the details of a theoretical study of the economic advantages of using large-scale energy storage to complement a wind farm in a base-load dominated electricity grid. A computer model is developed which simulates the operation of several energy storage systems when used with the 190-MW Portland wind farm (PWF) located in Portland, Victoria, Australia. A variety of operating strategies are compared with the results of a dynamic programming model which finds the maximum possible revenue which a given system can generate for a set of input conditions. Three energy storage systems are modelled and costed: pumped seawater hydro storage (PSHS), compressed air energy storage (CAES), and thermal energy storage (TES). It is found that CAES is the most profitable storage medium, requiring a capital expenditure of A$140 million and generating a rate of return (ROR) of 15.4%. The ROR for PSHS was 9.6%, and for TES was 8.0%. Therefore, a significant investment opportunity exists for the installation of an energy storage system in this wind farm. It is therefore highly recommended that CAES is investigated further with the aim of introducing large-scale energy storage to PWF and other similar wind turbine installations.

12/01491 Effects of electrical and mechanical parameters on the transient voltage stability of a fixed speed wind turbine

Dusonchet, L. and Telaretti, E. *Electric Power Systems Research*, 2011, 81, (7), 1308–1316.

In this paper the dynamic behaviour of a wind turbine connected to the grid is examined. The model of the fixed speed wind turbine has been developed with the Simulink simulation tool (Matlab Inc.) It is composed of the induction generator, the shaft system, an aerodynamic model of the wind turbine rotor and the pitch control system. Using this model, a three-phase fault is applied close to the wind turbine and cleared by disconnecting the faulty line. The rigorous implementation of the Simulink model allowed the authors to evaluate the exact dependence of various electrical parameters for the induction generator on voltage stability. Furthermore, the effects of wind turbine mechanical construction and of grid parameters on voltage stability are also evaluated and discussed. For each parameter, the terminal voltage and the generator rotor speed for different fault-clearing times are drawn. Finally, the terminal voltage and the generator rotor speed obtained for a fifth order model of the induction generator are compared with those obtained for a third order model. The differences between the two models are discussed. The results will help to understand transient stability phenomena in wind farms.

12/01492 Large-scale integration of wind power into the existing Chinese energy system

Liu, W. *et al. Energy*, 2011, 36, (8), 4753–4760.

This paper presents the ability of the existing Chinese energy system to integrate wind power and explores how the Chinese energy system needs to prepare itself in order to integrate more fluctuating renewable energy in the future. With this purpose in mind, a model of the Chinese energy system has been constructed by using EnergyPLAN based on the year 2007, which has then been used for investigating three issues. First, the accuracy of the model itself has been examined and then the maximum feasible wind power penetration in the existing energy system has been identified. Finally, barriers have been discussed and suggestions proposed for the Chinese energy system to integrate large-scale renewable energy in the future. It is concluded that the model constructed by the use of EnergyPLAN can accurately simulate the Chinese energy system. Based on current regulations to secure grid stability, the maximum feasible wind power penetration in the existing Chinese energy system is approximately 26% from both technical and economic points of view. A fuel efficiency decrease occurred when increasing wind power penetration in the system, due to its rigid power supply structure and the task of securing grid stability, was left primarily to large coal-fired power plants. There are at least three possible solutions for the Chinese energy system to integrate large-scale fluctuating renewable energy in the long term: redesigning the regulations to secure grid stability by means of diversifying the participants, such as including hydropower and CHP plants; integrating large-scale heat pumps combined with heat storage devices to satisfy district heat demands and developing electric vehicles to promote off-peak electricity utilization.

12/01493 Line overload alleviation through corrective control in presence of wind energy

Vergnol, A. *et al. Electric Power Systems Research*, 2011, 81, (7), 1583–1591.

With the growth of wind energy for power generation, several transmission system operators (TSOs) have increasing difficulties to forecast congestions due to the unpredictable nature of the energy source. This paper proposes to enhance congestion management using a real time supervisor. This supervisor performs automatic and dynamic re-dispatchings using both variable speed wind generators and conventional generators. In order to minimize production constraints, the real time congestion management system is based on an indicator of the efficiency of a re-dispatching on the power flowing in an overloaded line. This approach leads to reduced re-dispatching costs and increased network reliability. The simulation of the IEEE 14-bus test power system enhanced by the supervision system is done using the software 'EUROSTAG'. Grid integration of renewable generation is therefore increased through renewable production maximization while ensuring network security.

12/01494 Low and high voltage ride-through of DFIG wind turbines using hybrid current controlled converters

Mohseni, M. *et al. Electric Power Systems Research*, 2011, 81, (7), 1456–1465.

Doubly fed induction generators have been recognized as the dominant technology used in wind generation systems. However, this type of wind generator is very sensitive to the drop/rise in the supply voltage and without efficient 'ride-through' strategy, continuous operation of DFIG may fail due to destructive overcurrents in the rotor winding or large overvoltages in the dc-link capacitor. This paper introduces a hybrid current control scheme, implemented in the rotor-side and grid-side converters of DFIG, to enhance low and high voltage ride-through capacities of DFIG-based wind turbines. The proposed control scheme is constituted of two switching strategies integrated with a supervisory control unit: standard PI current controllers for normal operating conditions and vector-based hysteresis current controllers for DFIG protection during severe voltage sag/swell conditions. Time-domain simulation studies are carried out to examine the effectiveness of the proposed ride-through strategy under various types of grid disturbances. It is shown that the proposed controller constrains the rotor current and dc-link voltage within the safety limits of DFIG and as a result, the wind generator can comply with the strict low/high voltage ride-through requirements stipulated by modern grid codes.

12/01495 Offshore wind development in China and its future with the existing renewable policy

Yu, J. and Zheng, J. *Energy Policy*, 2011, 39, (12), 7917–7921.

Based on independent studies, this paper focuses on the significant discrepancy of 15 GW between the installed onshore wind generation capacity and what has been actually connected to the power network to reveal the challenges in meeting the Chinese renewable energy target. The recent accidents in Chinese north-western transmission network (in February to April 2011) demonstrated the urgent need for a fundamental review of the Chinese renewable energy policy. Offshore wind has been identified as the most feasible alternative to onshore wind to help deliver electricity to eastern China during the summer peak time. By investigating and summarizing first-hand experiences of participation in the Chinese renewable market, the authors provide the economic figures of the first cohort of Chinese offshore wind schemes. Large state-owned enterprises are dominating the offshore wind development, repeating their previous practices on the land. While this paper acknowledges the critical role of offshore wind generation in meeting Chinese renewable energy targets, it envisages an installed offshore capacity of approximately 2000 MW by 2015, much less than the 10,000 MW governmental estimation, which can be attributed to the lack of detailed energy policy, network constraints, offshore wind installation difficulties and quality issues in the manufacture of turbines.

12/01496 Offshore wind power grid connection – the impact of shallow versus super-shallow charging on the cost-effectiveness of public support

Weißensteiner, L. *et al. Energy Policy*, 2011, 39, (8), 4631–4643.

Public support for electricity generation from renewable energy sources is commonly funded by non-voluntary transfers from electricity consumers to producers. Apparently, the cost-effective disposition of funds in terms of induced capacity deployment has to be regarded a key criterion for the success of renewable energy policy. Grid connection costs are a major cost component in the utilization of offshore wind energy for electricity generation. In this paper, the effect of different attribution mechanisms of these costs on overall cost-effectiveness from consumers' perspective is analysed. The major result of this investigation is that an attribution of grid connection costs to grid operators – as against to generators – leads to a smaller producer surplus and, hence, to lower transfer costs for electricity consumers. Applying this approach to the deployment of UK rounds II and III offshore wind farms could lead to annual savings of social transfers of £1.2 billion and an equal reduction of producer surplus. This amount would be sufficient to finance the deployment of additional 10% of the capacity under consideration.

12/01497 The Darrieus wind turbine: proposal for a new performance prediction model based on CFD

Castelli, M. R. *et al. Energy*, 2011, 36, (8), 4919–4934.

This paper presents a CFD model for the evaluation of energy performance and aerodynamic forces acting on a straight-bladed vertical-axis Darrieus wind turbine. The basic principles which are currently applied to BE-M theory for rotor performance prediction are transferred to the CFD code, allowing the correlation between flow geometric characteristics (such as blade angles of attack) and dynamic quantities (such as rotor torque and blade tangential and normal forces). The model is proposed as a powerful design and optimization tool for the development of new rotor architectures for which test data is not available. After describing and validating the computational model against experimental data, a full campaign of simulation is proposed for a classical NACA 0021 three-bladed rotor. Flow field characteristics are investigated for several values of tip speed ratio, allowing a comparison among rotor operation at optimum and lower C_p values, so that a better understanding of vertical-axis wind turbines basic physics is obtained.

12/01498 Thermodynamic performance assessment of wind energy systems: an application

Redha, A. M. *et al. Energy*, 2011, 36, (7), 4002–4010.

In this paper, the performance of wind energy system is assessed thermodynamically, from resource and technology perspectives. The thermodynamic characteristics of wind through energy and exergy analyses are considered and both energetic and exergetic efficiencies are studied. Wind speed is affected by air temperature and pressure and has a subsequent effect on wind turbine performance based on wind reference temperature and Bernoulli's equation. VESTAS V52 wind turbine is selected for (Sharjah, UAE). Energy and exergy efficiency equations for wind energy systems are further developed for practical applications. The results show that there are noticeable differences between energy and exergy efficiencies and that exergetic efficiency reflects the right/actual performance. Finally, exergy analysis has been proven to be the right tool used in design, simulation, and performance evaluation of all renewable energy systems.

12/01499 Wind power forecasting uncertainty and unit commitment

Wang, J. *et al. Applied Energy*, 2011, 88, (11), 4014–4023.

In this paper, the authors investigate the representation of wind power forecasting (WPF) uncertainty in the unit commitment (UC) problem. While deterministic approaches use a point forecast of wind power output, WPF uncertainty in the stochastic UC alternative is captured by a number of scenarios that include cross-temporal dependency. A comparison among a diversity of UC strategies (based on a set of realistic experiments) is presented. The results indicate that representing WPF uncertainty with wind power scenarios that rely on stochastic UC has advantages over deterministic approaches that mimic the classical models. Moreover, the stochastic model provides a rational and adaptive way to provide adequate spinning reserves at every hour, as opposed to increasing reserves to predefined, fixed margins that cannot account either for the system's costs or its assumed risks.

12/01500 Wind power investment within a market environment

Baringo, L. and Conejo, A. J. *Applied Energy*, 2011, 88, (9), 3239–3247.

Within an existing transmission network, this paper considers the problem of identifying the wind power plants to be built by a wind power investor to maximize its profit. For this analysis a future target year is considered and the loads at different buses are represented by stepwise load–duration curves. The stochastic nature of both load and wind is represented via scenarios. The considered electric energy system operates under a pool-market arrangement and each producer/consumer is paid/pays the local marginal price (LMP) of the bus at which it is located. The higher the wind penetration is, the lower the resulting LMPs. To tackle this problem a stochastic bilevel model is proposed, whose upper-level represents the wind investment and operation decisions with the target of maximizing profits; and its lower-level represents the market clearing under differing load and wind conditions and provides LMPs. This model can be recast as a mixed-integer linear programming problem solvable using commercially available branch-and-cut solvers. The proposed model is illustrated using an example and two case studies.

12/01501 Wind profile assessment at Masitise and Sani in Lesotho for potential off-grid electricity generation

Mpholo, M. *et al. Energy Conversion and Management*, 2012, 53, (1), 118–127.

Wind profile of two sites, one on the southern part of Lesotho, Masitise (−30.367445° latitude, 27.669641° longitude, 1700 m altitude), and the other on the eastern part, Sani (−29.58273° latitude, 29.287845° longitude, 2900 m altitude), was analysed. Wind speed measurements for Masitise are taken at both 10 m and 25 m above ground level (a.g.l.) while for Sani anemometers are only placed at 9 m a.g.l. Both sites fall under the zero roughness class with bi-annual wind speed of 4.93 m/s and 5.50 m/s at 10 m and 9 m a.g.l., respectively. Moreover, their power densities are given by 121.6 W/m^2 and 221.3 W/m^2. A model using Weibull distribution function is used to analyse the wind speed profile. The results compare well with the Wind Atlas Analysis and Application program. According to the global wind power classification, Masitise is a class 2 site while the windier site of Sani falls under class 3. Masitise may not be ideal for grid-connected electricity production but both sites have sufficient wind for off-grid electricity production. On average the turbines will be generating 80% and 75% of the time per annum at Masitise and Sani, respectively.

12/01502 Wind turbines and coastal recreation demand

Landry, C. E. *et al. Resource and Energy Economics*, 2012, 34, (1), 93–111.

The impact of coastal wind turbines is examined on local coastal tourism and recreation for residents of the north-eastern coastal counties in North Carolina. A combination of telephone and web survey data are used to assess the impact of coastal wind farms on trip behaviour and site choice. Most of the respondents to the telephone survey claimed to support offshore wind energy development, and independent survey data suggested that the observed levels of support may be indicative of the broader population in this region. Overall, very little impact of coastal wind turbines was found on aggregate recreational visitation; loss in annual consumer surplus associated with widespread wind development in the coastal zone is insignificant at $17 (or about 1.5% of annual consumer surplus). Results suggest that North Carolina local coastal tourists are averse to wind farms in the near-shore zone; average compensating variation for wind farms one mile from the shore is estimated at $55 per household. On average, no evidence of aversion to wind farms 4 miles out in the ocean was found, or for wind farms located in coastal estuaries. For all wind farm scenarios, evidence of preference heterogeneity is found: some respondents find this appealing while others find it aversive.

Others, including economics

12/01503 A novel combined solar concentration/wind augmentation system: constructions and preliminary testing of a prototype

Tao, T. *et al. Applied Thermal Engineering*, 2011, 31, (17–18), 3664–3668.

This study presents construction and preliminary testing of a prototype combined solar concentration/wind augmentation (CSCWA) system, which uses a single slightly deep parabolic dish. The dish concentrator in the prototype CSCWA system has a front opening of 1 m diameter, a base opening of 0.5 m diameter and a depth of 0.5 m. A Rutland 503 wind turbine is installed within a short duct connected to the base opening of the concentrator. A 80 mm × 70 mm PV module is installed at the centre of the duct and slightly away from the hub of the wind turbine. The prototype CSCWA system is installed on a two-axis solar tracking system. The preliminary testing will be carried out to investigate I–V and operating characteristics of the concentrating PV module under the sunny sky and the wind turbine in the windy weather. These results will provide a basis for the system control design and analysis of its feasibility.

12/01504 A risk-averse optimization model for trading wind energy in a market environment under uncertainty

Pousinho, H. M. I. *et al. Energy*, 2011, 36, (8), 4935–4942.

In this paper, a stochastic programming approach is proposed for trading wind energy in a market environment under uncertainty. Uncertainty in the energy market prices is the main cause of high volatility of profits achieved by power producers. The volatile and intermittent nature of wind energy represents another source of uncertainty. Hence, each uncertain parameter is modelled by scenarios, where each scenario represents a plausible realization of the uncertain parameters with an associated occurrence probability. Also, an appropriate risk measurement is considered. The proposed approach is applied on a realistic case study, based on a wind farm in Portugal. Finally, conclusions are duly drawn.

12/01505 Are participators in the land retirement program likely to grow energy crops?

Chang, H.-H. and Chen, Y.-H *Applied Energy*, 2011, 88, (9), 3183–3188.

Due to the increasing demand for energy, interaction between land use and energy-related crop production has recently become a subject of great attention. Although a considerable body of literature has examined the extent to which the increased demand for biofuel may impact agricultural land use, little evidence has been provided as result of farmer level surveys. Using a unique and national representative survey of all eligible farmers in the land retirement program in Taiwan in 2005, this study examines the interaction between the land retirement program and energy crop production. Results points to a positive association between the enrolled land area and the likelihood of energy crop production. However, the magnitude of the effects is not substantial. This may reflect the fact that the current subsidy to farmers to grow energy crops on their fallow land is not high enough to provide strong incentive.

12/01506 Assessing the economic efficiency of bioenergy technologies in climate mitigation and fossil fuel replacement in Austria using a techno-economic approach

Kalt, G. and Kranzl, L. *Applied Energy*, 2011, 88, (11), 3665–3684.

The core issues of the Austrian energy policy agenda include reducing greenhouse gas (GHG) emissions and dependence on fossil fuels. Within this study, the costs of GHG mitigation and fossil fuel replacement (abatement costs) of established and upcoming bioenergy technologies for heat, electricity and transport fuel production are assessed. Sensitivity analyses and projections up to 2030 illustrate the effect of dynamic parameters on specific abatement costs. The results show that the abatement costs of wood-based heat generation technologies substituting oil-fired boilers and gas-fired heating plants, respectively, are in the range of −45 € per ton CO_2-equivalent (€/t CO_2-eq.) and −11 € per MW h higher heating value (€/MW h_{HHV}) to 93 €/t CO_2-eq. and 24 €/MW h_{HHV}. Heating systems around 50 kW show the lowest abatement costs. For combined heat and power (CHP) plants, two different cases with regard to heat utilization are assumed. In an optimal mode (100% of generated heat displaces fossil fuel-based heat production), abatement costs of wood-based technologies, substituting electricity from modern combined cycle gas turbines, range from 5 €/t CO_2-eq. and 1 €/MW h_{HHV} to 201 €/t CO_2-eq. and 38 €/MW h_{HHV}. Representative values of typical CHP plants with a capacity of 1 MW_{el} and more are in the magnitude of 50 €/t CO_2-eq. and 10 €/MW h_{HHV}. Under less favourable conditions (3000 heat full load hours per year), abatement costs of typical plants are around 100 €/t CO_2-eq. and 17 €/MW h_{HHV} higher. The costs of GHG mitigation and fossil fuel saving with established transport fuels (biodiesel and ethanol) range from 71 €/t CO_2-eq. and 8 €/MW h_{HHV} to 200 €/t CO_2-eq. and 82 €/MW h_{HHV}. For liquid fuels from lignocellulosis, abatement costs are estimated 147 €/t CO_2-eq. and 38 €/MW h_{HHV} to 240 €/t CO_2-eq. and 59 €/MW h_{HHV}. The abatement costs of synthetic natural gas are found to be significantly lower: 75 €/t CO_2-eq. and 14 €/MW h_{HHV} to 128 €/t CO_2-eq. and 23 €/MW h_{HHV}. The results suggest that heat generation and – given favourable conditions – CHP generation are the most cost-efficient options for reducing GHG emissions and fossil fuel dependence in Austria. A core advantage of CHP is higher quantities of abatement per unit of biomass used. In contrast, this is found to be the main drawback of synthetic transport fuels from wood.

12/01507 Assessment of the feed-in tariff mechanism for renewable energies in Taiwan

Huang, Y.-S. and Wu, J.-H. *Energy Policy*, 2011, 39, (12), 8106–8115.

Due to Taiwan's lack of natural resources, dependence on imported energy, and pursuit of sustainable development, renewable energies are extremely important for Taiwan's future energy supply. Since Taiwan's feed-in tariff (FIT) is still in its initial stage, one must examine whether the current system is compatible with a well-designed FIT scheme. This study examines the main features of Taiwan's FIT system and assesses design options using several criteria. Additionally, one of the most important elements of a FIT scheme, namely, a tariff system, is discussed. Taiwan's FIT scheme has the design options required by well-functioning FITs, and the guaranteed-return tariff system coincides with the spirit underlying leading global FITs; however, many issues, such as setting goals by stages, refinement of the tariff calculation methodology, and elimination of other non-economic barriers, must be addressed to achieve future developmental goals and green industry growth.

12/01508 Biofuel and petroleum-based fuel supply chain research: a literature review

An, H. *et al. Biomass and Bioenergy*, 2011, 35, (9), 3763–3774.

During the past decade, countries around the world – especially the USA, Brazil, and many in Europe – have worked to accelerate the commercialization of a biofuel industry. As pilot plant studies for the second-generation biofuel (e.g. cellulosic biofuel) currently seek to determine the most viable feedstocks and processing technologies, it is an opportune time to formulate operations research (OR) models of the biofuel supply chain (SC) so they might be used to implement the technologies that prove to be most promising. This paper provides a literature review of research on the biofuel SC. It classifies prior research according to decision time frame (i.e. strategic, tactical, operational, and integrated) as well as level in the supply chain (i.e. upstream, midstream, and downstream). In addition, it reviews related research on agri-products, which have some commonalities relative to harvesting and perishability; petroleum-based fuels, which have some commonalities related to distribution (some biofuels can be mixed with gasoline but others cannot); and generic supply chains, which provide some applicable modelling structures. Finally, this paper emphasizes unique needs to support decisions that integrate the farm with commercial levels (e.g. storage, pre-processing, refining, and distribution) and identifies fertile avenues for future research on the biofuel supply chain. OR models are needed to help assure the economic viability of the biofuel industry. They can be used by growers, processors, and distributors to design and manage an integrated system and by government to inform policies needed to stimulate the growth of the industry and, perhaps, subsidize it.

12/01509 Choosing the site for the first wave farm in a region: a case study in the Galician southwest (Spain)

Iglesias, G. and Carballo, R. *Energy*, 2011, 36, (9), 5525–5531.

Where should the first wave farm in a region be installed? The nearshore area with the largest resource is the prime candidate. But how should this area be determined? Wave resource analyses typically consider a small number of wave patterns. Does the number of wave patterns influence the outcome? And, more generally, what is the best procedure for selecting the area? This work proposes an approach based on a large number of nearshore wave patterns and applies it to the Galician south-west, where the first administrative concession for a wave farm (at a site to be determined) is expected to be issued shortly. The sensitivity of the results to the number of wave patterns, hence to the percentages of the total annual energy and time covered in the analysis, is investigated. It is found that the area that emerges as having the largest resource does depend on these percentages. For this reason, conventional analyses based on a small number of wave patterns are not sufficient to reliably determine the area with the largest resource. It is necessary to ensure that a sufficiently large percentage of the total energy is considered, using a procedure like the one proposed in this work.

12/01510 Consumers' preference for renewable energy in the southwest USA

Mozumder, P. *et al. Energy Economics*, 2011, 33, (6), 1119–1126.

The south-western part of the USA has an abundant supply of renewable energy resources but little is known about the consumers' preferences for renewable energy in this region. This paper investigates households' willingness to pay (WTP) for a renewable energy program in the south-western state of New Mexico. Using the contingent valuation method, different scenarios are provided that include provision of 10% and 20% of renewable energy supply, to elicit households' WTP for the renewable energy. The WTP for specific shares of renewable energy in the total energy mix is estimated as it is a key factor in affecting the price of the energy portfolio in the market. The survey design also allows the checking of the scope sensitivity of renewable energy which can help guide the future renewable energy policy. The authors hope results from this study will offer useful insights to energy regulators and utility companies and help them increase the share of renewable energy supply.

12/01511 Development and performance evaluation of natural thermal-insulation materials composed of renewable resources

Korjenic, A. *et al. Energy and Buildings*, 2011, 43, (9), 2518–2523.

Because energy efficiency in buildings will be evaluated not only based on heating demand, but also according to the primary energy demand, the ecological properties of the building materials for the whole assessment has become essential. The demand for green building materials is rising sharply, especially insulating materials from renewable resources. The application of natural materials has become increasingly important as a consequence of the increasing need to conserve energy, use natural materials, incorporate architecture and construction into sustainable development processes, and the recently promulgated discussions on appropriate disposal of used insulation materials such as polystyrene (EPS). Due to the fact that natural materials are more sensitive to moisture, decomposition factors such as temperature, material moisture content, attacks by microorganisms, and possible decomposition of the material or shorter durability, it is necessary to evaluate the degradation rate of built-in materials and also determine their real in situ hygrothermal properties according to their moisture content, and volume changes. This paper describes the results of a research project carried out at the Vienna University of Technology and Brno University of Technology. The objective is to use jute, flax, and hemp to develop a new insulating material from renewable resources with comparable building physics and mechanical properties to commonly used insulations materials. All input components are varied in the tests. The impact of moisture content changes in relation to the rate of change of other properties was the focus of the investigation. The tests results show that the correct combination of natural materials is absolutely comparable with convectional materials.

12/01512 Economic analysis of fuel ethanol production from winter hulled barley by the EDGE (enhanced dry grind enzymatic) process

Nghiem, N. P. *et al. Bioresource Technology*, 2011, 102, (12), 6696–6701.

A process and cost model was developed for fuel ethanol production from winter barley based on the enhanced dry grind enzymatic (EDGE) process. In this process, in addition to β-glucanases, which are added to reduce the viscosity of the mash, β-glucosidase is also added to completely hydrolyse the oligomers obtained during the hydrolysis of β-glucans to glucose. The model allows determination of capital costs, operating costs, and ethanol production cost for a plant producing 40 million gallons of denatured fuel ethanol annually. A sensitivity study was also performed to examine the effects of β-glucosidase and barley costs on the final ethanol production cost. The results of this study clearly demonstrate the economic benefit of adding β-glucosidase. Lower ethanol production cost was obtained compared to that obtained without β-glucosidase addition in all cases except one where highest β-glucosidase cost allowance and lowest barley cost were used.

12/01513 Hydro energy potential of cooling water at the thermal power plant

Stevanovic, V. D. *et al. Applied Energy*, 2011, 88, (11), 4005–4013.

The hydro energy of the gravity water flow from the coal-fired thermal power plant units to the river in an open cooling system of turbine condensers is determined. On the basis of statistical data for a long time period, the water net head duration curve due to the river annual level change, as well as the reduction of the hydro energy potential due to the thermal power plant overhauls periods, are evaluated in the case study of the thermal power plant 'Nikola Tesla B' in Serbia. A small hydro power plant is designed for the utilization of this hydro energy, and the economic benefits of the project are calculated. The internal rate of returns and pay back periods are calculated in dependence of the electricity price and total investment costs. The increase of profitability is assessed, bearing in mind that the plant might be realized as the clean development mechanism project according to the Kyoto Protocol. The obtained results show that the project is economically attractive, and it can be carried out with standard matured solutions of hydro turbines available at the market. Even for the relatively low electricity price from small hydro power plants in Serbia of 0.08 €/kW h the internal rate of return and the payback period are 17.5% and 5.5 years.

12/01514 Interconnection of decentralized renewable resources into distribution grids: implications and planning aspects

Hemdan, N. G. A. and Kurrat, M. *Electric Power Systems Research*, 2011, 81, (7), 1410–1423.

This work discusses the implications of interconnection of decentralized wind power generation on a real-life medium voltage distribution grid. Using measured wind generation data and simulated load profiles of the households, which are connected to the LV side at each MV substation, the impacts on voltage ranges, voltage profiles, line loading, and energy losses are analysed. The availability to integrate a new wind mill into the grid which already contains three wind mills is examined with respect to the technical conditions for generation connection to the MV grids introduced by German Association of the Energy and Water Industries.

12/01515 Investing in biogas: timing, technological choice and the value of flexibility from input mix

Di Corato, L. and Moretto, M. *Energy Economics*, 2011, 33, (6), 1186–1193.

In a stochastic dynamic frame, the technology choice problem of a continuous co-digestion biogas plant is studied where input factors are substitutes but need to be mixed together to provide output. Given any initial rule for the composition of the feedstock, the possibility of revising it if economic circumstances make it profitable is considered. Flexibility in the mix is an advantage under randomly fluctuating input costs and comes at a higher investment cost. The authors show that the degree of flexibility in the productive technology installed depends on the value of the option to profitably re-arrange the input mix. Such option adds value to the project in that it provides a device for hedging against fluctuations in the input relative convenience. Accounting for such value, the trade-off between investment timing and profit smoothing flexibility is discussed.

12/01516 Irreversible investment, uncertainty, and ambiguity: the case of bioenergy sector

Jouvet, P.-A. *et al. Energy Economics*, 2012, 34, (1), 45–53.

This paper analyses production and investment decisions of an agent in industrial activities that are characterized by two forms of uncertainty: demand uncertainty (in terms of number of buyers) and competitive effect uncertainty (in terms of other energy resource). The model is applied to the bioenergy industries. The case of an ambiguity neutral agent is compared with that of an ambiguity averse agent. The authors show that the investment decision of an agent depends on the effects of both the capital investment and the level of production on the cost and the uncertainty the agent is confronted with. Moreover, it is found that ambiguity aversion tends to decrease the agent's optimal levels of production and investment. The numerical analysis of the French case illustrates the different effects associated with demand uncertainty and competitive effect uncertainty.

12/01517 Long term operation of a solar assisted ground coupled heat pump system for space heating and domestic hot water

Chen, X. *et al. Energy and Buildings*, 2011, 43, (8), 1835–1844.

This paper introduces a solar-assisted ground-coupled heat pump (SAGCHP) system with heat storage for space heating and domestic hot water (DHW) supply. The simulation results of the system's detailed operating performance are presented. The optimization of the system design is carried out by the TRNSYS and a numerical simulation is performed for continuous operation of 20 years under the meteorological conditions of Beijing. Different control strategies are considered and the operational characteristics of each working mode are studied. The simulating results show that the long-term yearly average space heating efficiency is improved by 26.3% compared to a traditional ground coupled heat pump (GCHP) system because the solar thermal collecting system is used to elevate the thermal energy in the soil and to provide direct space heating with heat storage. At the same time, the underground heat load imbalance problem for a heating load dominated GCHP is solved by soil recharging during non-heating periods, while extra solar energy is utilized to supply DHW. The flexibility and high efficiency of the SAGCHP system could offer an alternative for space heating and DHW supply by heat pump technology and solar energy in cold winters of northern China.

12/01518 Low carbon housing refurbishment challenges and incentives: architects' perspectives

Davies, P. and Osmani, M. *Building and Environment*, 2011, 46, (8), 1691–1698.

The UK has a legally binding commitment to reduce CO_2 levels by 80% by 2050 relative to the 1990 emissions baseline. The existing housing stock, which accounts for approximately 30% of total UK energy demand, has the potential to provide significant opportunities for this reduction; however, currently there are no legislative measures driving widespread low carbon housing refurbishment (LCHR) design and construction. Architects have a decisive role to move forward the LCHR agenda owing to their leadership and significant involvement in the initial briefing, conceptual and design development phases of a project, regardless of project procurement types and project sizes. Hence, the aim of this research is to investigate the key challenges and incentives for achieving LCHR in England from architects' perspectives. The research adopted a triangulated methodological approach, consisting of a desk study, postal questionnaires, and follow up semi-structured interviews. The questionnaires and interviews were executed amongst a wide geographical sampling frame of architects in England with previous housing refurbishment experience. The research concluded that high capital costs for micro-generation technologies and energy efficient materials; disparity in value added tax (VAT) between new build and refurbishment; and the complexity of the UK existing housing stock are the most considerable LCHR challenges. In contrast, the research indicated that a tax rebate; removal of the VAT difference between new build and refurbishment; increased research to produce affordable micro-generation technologies; and increased government supplied low carbon programmes were identified by the participants as the key incentives to drive the LCHR agenda.

12/01519 Membrane air-conditioning system driven by renewable energy

Li, X.-W. *et al. Energy Conversion and Management*, 2012, 53, (1), 189–195.

An absorption air-conditioning system has many advantages over a vapour compression air-conditioning system. The absorption system is more environmentally friendly, capable of using low-grade heat and less dependent on electrical power. However, because of the low efficiency of energy usage, the performance of the absorption system is not yet as competitive as the vapour compression system. To improve this, a novel membrane absorption system is proposed in this paper. A regenerator consists of stacks with ion-exchange membranes, takes the places of the generator and the condenser; the electric energy gained from solar or wind power is used to drive this system. A primary analysis has been made and the results show that this proposed membrane absorption air-conditioning system can raise its coefficient of performance as high as, or even higher than that of the vapour compression system when the absorbent is LiBr solution, of which the mass concentration is below 52%, and the applied voltage is no more than 100 V.

12/01520 Net energy analysis of the production of biodiesel and biogas from the microalgae: *Haematococcus pluvialis* and *Nannochloropsis*

Razon, L. F. and Tan, R. R. *Applied Energy*, 2011, 88, (10), 3507–3514.

Microalgae have been proposed as possible alternative feedstocks for the production of biodiesel because of their high photosynthetic efficiency. The high energy input required for microalgal culture and oil extraction may negate this advantage, however. There is a need to determine whether microalgal biodiesel can deliver more energy than is required to produce it. In this work, net energy analysis was done on systems to produce biodiesel and biogas from two microalgae: *Haematococcus pluvialis* and *Nannochloropsis*. Even with very optimistic assumptions regarding the performance of processing units, the results show a large energy deficit for both systems, due mainly to the energy required to culture and dry the microalgae or to disrupt the cell. Some energy savings may be realized from eliminating the fertilizer by the use of wastewater or, in the case of *H. pluvialis*, recycling some of the algal biomass to eliminate the need for a photobioreactor, but these are insufficient to completely eliminate the deficit. Recommendations are made to develop wet extraction and transesterification technology in order to make microalgal biodiesel systems viable from an energy standpoint.

12/01521 Ordering the extraction of renewable resources: the case of multiple aquifers

Roumasset, J. A. and Wada, C. A. *Resource and Energy Economics*, 2012, 34, (1), 112–128.

Optimal sequencing of resource extraction is typically studied for non-renewable resources. Conditions for optimal use of multiple sources of a renewable resource are provided and characterize the resulting extraction sequence, resource scarcity values, and (single) efficiency price path for two groundwater aquifers and an abundant alternative resource. Even with one demand, the optimal sequence depends on the differential opportunity costs of the two renewables. A numerical simulation for the South O'ahu aquifer system, which also allows for different distribution costs, illustrates the case of using the 'leakier' aquifer first and then switching to simultaneous use of both resources. The welfare gain from specialization relative to independent management is $4.7 billion.

12/01522 Perception of risks in renewable energy projects: the case of concentrated solar power in north Africa

Komendantova, N. *et al. Energy Policy*, 2012, 40, 103–109.

The world needs to reduce greenhouse gas emissions to prevent climate change, while meeting the energy needs of developed and developing economies. Recent studies suggest that generation of electricity from concentrated solar power in north African countries and its transmission to Europe could provide European and north African partners with low-carbon electricity. The private capital will be likely required to achieve the scale of new investment and yet the north African region experience difficulties with sustaining high levels of foreign direct investment from the private sector. The literature identifies a number of risks as barriers to investment, and the authors examine these in the particular context of renewable energy development. Three stages of interviews were conducted with stakeholders to learn their perceptions of the risks most likely to affect renewable energy projects. Three class of risks – regulatory, political, and *force majeure* (which includes terrorism) – stand out as being of high concern. Of these, regulatory risks are perceived as being the most consequential, and the most likely to occur. This suggests that attention to building the capacities of North African countries to develop, implement, and enforce sound regulations in a transparent manner could be an important step in promoting renewable energy co-operation with Europe.

12/01523 Techno-economic analysis of a wind–solar hybrid renewable energy system with rainwater collection feature for urban high-rise application

Chong, W. T. *et al. Applied Energy*, 2011, 88, (11), 4067–4077.

The technical and economic feasibility study of an innovative wind–solar hybrid renewable energy generation system with rainwater collection feature for electrical energy generation is presented in this paper. The power generated would supply part of the energy requirements of the high-rise building where the system is installed. The system integrates and optimizes several green technologies; including urban wind turbine, solar cell module and rain water collector. The design was conceptualized based on the experiences acquired during the development and testing of a suitable wind turbine for Malaysian applications. It is compact and can be built on top of high-rise buildings in order to provide on-site renewable power to the building. It overcomes the inferior aspect on the low wind speed by channelling and increasing the speed of the high altitude free-stream wind through the power-augmentation-guide-vane (PAGV) before it enters the wind turbine at the centre portion. The shape or appearance of the PAGV that surrounds the wind turbine can be blended into the building architecture without negative visual impact (becomes part of the building). The design improves the starting behaviour of wind turbines. It is also safer to people around and reduces noise pollution. The techno-economic analysis is carried out by applying the life cycle cost method. The life cycle cost method takes into consideration the complete range of costs and makes cash flows time-equivalent. The evaluations show that for a system with the PAGV (30 m diameter and 14 m high) and an H-rotor vertical axis wind turbine (17 m diameter and 9 m high) mounted on the top of a 220 m high building, the estimated annual energy savings is 195.2 MW h/year.

12/01524 The renewable energy targets of the Maghreb countries: impact on electricity supply and conventional power markets

Brand, B. and Zingerle, J. *Energy Policy*, 2011, 39, (8), 4411–4419.

Morocco, Algeria and Tunisia, the three countries of the North African Maghreb region, are showing increased efforts to integrate renewable electricity into their power markets. Like many other countries, they have pronounced renewable energy targets, defining future shares of 'green' electricity in their national generation mixes. The individual national targets are relatively varied, reflecting the different availability of renewable resources in each country, but also the different political ambitions for renewable electricity in the Maghreb states. Open questions remain regarding the targets' economic impact on the power markets. This article addresses this issue by applying a linear electricity market optimization model to the North African countries. Assuming a competitive, regional electricity market in the Maghreb, the model minimizes dispatch and investment costs and simulates the impact of the renewable energy targets on the conventional generation system until 2025. Special emphasis is put on investment decisions and overall system costs.

12/01525 The willingness of farmers to engage with bioenergy and woody biomass production: a regional case study from Cumbria

Convery, I. *et al. Energy Policy*, 2012, 40, 293–300.

In this paper the authors explore the willingness of farmers in Cumbria, UK to switch land use from food production to biomass production in a landscape where food production is both heavily subsidized and the area is a centre for tourism. This is against a policy background of a switch of subsidies from food production to environmental benefits, increased concerns about emissions from farming and an increased demand for renewable energy. An awareness of new markets for renewable energy was identified, alongside increasing volatility of other crops (against a background of increasing demand for food). From this, the conclusions are that the main short-term opportunities for increasing biomass production in this region are through intensifying management of existing woodlands. In the medium term, as the financial case for biomass crops becomes more certain, a 'tipping point' can be envisaged which would favour a switch from marginal agricultural land to biomass.

12/01526 Wind generation imbalances penalties in day-ahead energy markets: the Italian case

Brunetto, C. and Tina, G. *Electric Power Systems Research*, 2011, 81, (7), 1446–1455.

The interest in wind energy exploitation has been emphasized by incentive mechanisms and the different potential ways of selling energy to the electrical market. The rise of wind-installed power has an impact on ancillary services and the imbalance costs that have to be sustained by the transmission system operator (TSO). To solve this problem some solutions can be adopted depending on market rules that are different from one country to another. In particular referring to the current Italian market framework and taking into account to the state-of-the-art wind power forecasting, an economic assessment of imbalance for some wind farms have been compared to balancing costs of the TSO. Different stochastic approaches have been adopted, using available historical data, in the analysis of various scenarios both for the TSO and for wind plant owners. Also possible mechanisms for imbalance settlements have been proposed in order to maintain grid safety costs within a reasonable level for electricity consumers, and to avoid an excessively penalizing treatment for wind energy source investments in order to satisfy environmental targets of the European Community.

14 FUEL SCIENCE AND TECHNOLOGY

Fundamental science, analysis, instrumentation

12/01527 A comparison of thermal comfort predictive control strategies

Castilla, M. *et al. Energy and Buildings*, 2011, 43, (10), 2737–2746.

Most of the time, people perform their daily activities inside buildings. Thus, an important factor is to look for a trade-off between energy saving and user welfare, since lack of poor indoor comfort has a direct effect on users' productivity and an indirect effect on energy efficiency. The use of appropriate control strategies can highly contribute to this purpose. This paper presents a comparison among several predictive control approaches that allow the possibility of obtaining a high thermal comfort level optimizing the use of an HVAC (heating, ventilation and air conditioning) system by means of different cost functions. Real results obtained in a solar energy research centre are included and commented.

12/01528 An intelligent approach to assessing the effect of building occupancy on building cooling load prediction

Kwok, S. S. K. *et al. Building and Environment*, 2011, 46, (8), 1681–1690.

Building cooling load prediction is one of the key factors in the success of energy-saving measures. Many computational models available in the industry have been developed from either forward or inverse modelling approaches. However, these models usually require extensive computer resources and lengthy computation. This paper discusses the use of the multi-layer perceptron (MLP) model, one of the artificial neural network (ANN) models widely adopted in engineering applications, to estimate the cooling load of a building. The training samples used include weather data obtained from the Hong Kong Observatory and building-related data acquired from an existing prestigious commercial building in Hong Kong that houses a mega complex and operates 24 h a day. The paper also discusses the practical difficulties encountered in acquiring building-related data. In contrast to other studies that use ANN models to predict building cooling load, this paper includes the building occupancy rate as one of the input parameters used to determine building cooling load. The results demonstrate that the building occupancy rate plays a critical role in building cooling load prediction and significantly improves predictive accuracy.

12/01529 Analytical derivation of explicit J–V model of a solar cell from physics based implicit model

Das, A. K. *Solar Energy*, 2012, 86, (1), 26–30.

Recently a simple explicit model was introduced to represent the J–V characteristics of an illuminated solar cell with parasitic resistances and bias dependent photocurrent as $v^m + j^n = 1$. Here the normalized voltage, v and normalized current density j can be represented as $v = V/V_{oc}$ and $j = J/J_{sc}$ respectively, where V_{oc} is the open circuit voltage and J_{sc} is the short circuit current density. This model is useful for design, characterization and simple fill factor calculation and its applicability was demonstrated with the measured data of a wide variety of solar cells. This explicit form is intuitive and hence the model lacks the analytical support. In this paper an analytical derivation of this closed form explicit model is presented, which is derived from the physics based implicit J–V equation. The derivation expands the scope of model applicability and provides a new insight of analytical modelling of the solar cell.

12/01530 Application of the mass action law to describe ion exchange equilibrium in a fixed-bed column

Borba, C. E. *et al. Chemical Engineering Journal*, 2011, 172, (1), 312–320.

Ion exchange experiments were carried out in a fixed-bed column employing the binary systems Cu^{2+}–Na^+ and Zn^{2+}–Na^+. Amberlite IR 120 was used as the ion exchange resin. The ion exchange dynamics within the column was described by a model considering the external mass transfer and the diffusion within the particle. A linear driving force model was used to represent the mass transfer within the resin particles. The model considered the thermodynamic equilibrium on the liquid–solid interface, which was described by the Langmuir isotherm and by the mass action law. The results indicate that both models represent well the ion exchange dynamics in all cases.

12/01531 Automatic generation of energy conservation measures in buildings using genetic algorithms

Siddharth, V. *et al. Energy and Buildings*, 2011, 43, (10), 2718–2726.

Building energy simulations are key to studying energy efficiency in buildings. The state-of-the art building energy simulation tools requires a high level of multidisciplinary domain expertise from the user and many technical data inputs that curb the usability of such programs. In this paper, an IT tool is presented, which has the capability of predicting a building's energy utilization configuration based on the reported annual energy and a few non-technical inputs from the user; and correspondingly generates cost-effective energy conservation measures for the intended savings. The approach first identifies the system variables that are critical to a building's energy consumption and searches for the combination of these parameters that would give rise to the annual energy consumption as reported by the facility. Genetic algorithms are utilized to generate this database. A statistical fit is formulated between the system variables and the annual energy consumption from the database. Using this correlation, system configuration for the target energy efficiency is determined with corresponding energy conservation measures. A cost analysis is carried out to prescribe the most cost-effective energy conservation measures. Competency of the tool is demonstrated in the paper through case studies on three geographies with different climate conditions.

12/01532 Batch estimation of statistical errors in the Monte Carlo calculation of local powers

Ueki, T. *Annals of Nuclear Energy*, 2011, 38, (11), 2462–2469.

Batch methodology is among the techniques for computing the standard deviation of sample mean and is applicable to any output series from stationary iteration cycles. In the present article, three forms of the methodology are investigated: non-overlapping batch means (NBM), overlapping batch means (OBM) and standardized time series (STS). In particular, they are applied to the MC calculation of local powers of a pressurized water reactor. The numerical results reveal that the performance of NBM is equivalent to that of OBM, whereas STS performs poorly for small batch sizes. It is also shown that OBM can be improved based on the method of autocovariance bias correction. For a computational condition leading to 0.5–1.5% statistical errors, the improved OBM for a batch size of 10% of the stationary iteration cycle length yields 88–103% of the reference value of standard deviation at tally cells where the sample standard deviation yields 22–36% of the same reference value.

12/01533 Calibrating whole building energy models: an evidence-based methodology

Raftery, P. *et al. Energy and Buildings*, 2011, 43, (9), 2356–2364.

This paper reviews existing case studies and methods for calibrating whole building energy models to measured data. This research describes a systematic, evidence-based methodology for the calibration of these models. Under this methodology, parameter values in the final calibrated model reference the source of information used to make changes to the initial model. Thus, the final model is based solely on evidence. Version control software stores a complete record of the calibration process, and the evidence on which the final model is based. Future users can review the changes made throughout the calibration process along with the supporting evidence. In addition to the evidence-based methodology, this paper also describes a new zoning process that represents the real building more closely than the typical core and four-perimeter zone approach. Though the methodology is intended to apply to detailed calibration studies with high resolution measured data, the primary aspects of the methodology (evidence-based approach, version control, and zone-typing) are independent of the available measured data.

12/01534 Charge fraction distribution of nucleation mode particles: new insight on the particle formation mechanism

Sgro, L. A. *et al. Combustion and Flame*, 2011, 158, (7), 1418–1425.

Particle size distributions of total and singly charged nanoparticles in premixed flames were measured with different flame stoichiometry and temperature to investigate particle inception. Particle charging in flames occurs by diffusion charging involving ions formed by chemi-ionization reactions in the flame front. It can be described by a Boltzmann charge fraction distribution evaluated at the local flame temperature where the particles interact with the chemi-ions. As the particles coagulate in the post flame zone, their charge fraction is reduced. The charge distribution of the coagulated aerosol again results in a Boltzmann curve, this time evaluated at the local post flame gas temperature where the particles had their last coagulation event. Particle nucleation in the post-flame zone, where chemi-ions are drastically reduced, produces uncharged particles. Considering the above charging processes, the charge fraction of the nucleation mode contains information on the location within the flame these particles were formed. The results show that in flames near the particle inception threshold, particles are charged close to the flame front and remain charged even late in the post flame zone. Furthermore, smaller particles undergo less charge neutralization by coagulation as they travel through the post flame zone than larger particles. A different scenario is observed in richer flames; the smaller particles eventually become uncharged, indicating that significant amounts of freshly nucleated particles in these flames are formed in the post flame zone. Whether nucleation preferentially occurs close to the flame front or persists into the post flame zone also depends on flame temperature.

12/01535 Effect of charge dilution on gaseous and particulate emissions from a diesel engine fueled with biodiesel and biodiesel blended with methanol and ethanol

Zhu, L. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2271–2278.

In this study, the effect of intake charge dilution with carbon dioxide on the combustion and emission characteristics of a four-cylinder direct-injection diesel engine fuelled with biodiesel, ethanol-biodiesel and methanol-biodiesel were investigated. With increase of intake CO_2 concentration, CO, HC, particulate mass concentration, particle number concentration and geometric diameter (GMD) of all fuels increased while NO_x decreased obviously. After addition of methanol and ethanol in biodiesel, the NO_x, particulate mass concentration and particle number concentration decreased at each intake CO_2 concentration, compared with biodiesel. Moreover, as the intake CO_2 concentration increased from 2% to 5.6%, particulate mass concentration of the alcohol-biodiesel blends remained almost unchanged. It means that the combination of alcohol-biodiesel blends with intake charge dilution could reduce the NO_x emission and maintains particulate mass concentration at a relatively low level.

12/01536 Electromagnetic and thermal history during microwave heating

Santos, T. *et al. Applied Thermal Engineering*, 2011, 31, (16), 3255–3261.

In microwave heating, the energy is directly introduced into the material resulting in a rapid and volumetric heating process with reduced thermal gradients, when the electromagnetic field is homogeneous. From those reasons, the microwave technology has been widely used in the industry to process dielectric materials. The capacity to heat with microwave radiation is related with the dielectric properties of the materials and the electromagnetic field distribution. The knowledge of the permittivity dependence with the temperature is essential to understand the thermal distribution and to minimize the non-homogeneity of the electromagnetic field. To analyse the history of the heating process, the evolution of the electromagnetic field, the temperature and the skin depth, were simulated dynamically in a ceramic sample. The evaluation of the thermal runaway has also been made. This is the most critical phenomenon observed in the sintering of ceramic materials because it causes deformations, or even melting on certain points in the material, originating the destruction of it. This study shows that during the heating process the hot spots have some dynamic, and at high temperatures most of the microwave energy is absorbed at the surface of the material. The existence of a time-delay of the thermal response with the electromagnetic changes is also demonstrated.

12/01537 Estimation of radiation losses from sheathed thermocouples

Roberts, I. L. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2262–2270.

Thermocouples are often used for temperature measurements in heat exchangers. However if the radiation losses from a thermocouple in a high temperature gas flow to colder surroundings are ignored significant errors can occur. Even at moderate temperature differences, these can be significant. Prediction of radiation losses from theory can be problematic, especially in situations where there are large variations in the measured temperatures as the emissivity and radiative heat transfer coefficient of the thermocouple are not constant. The following approach combines experimental results with established empirical relationships to estimate losses due to radiation in an annular heat exchanger at temperatures up to 950 °C.

12/01538 Estimation of wind speed profile using adaptive neuro-fuzzy inference system (ANFIS)

Mohandes, M. *et al. Applied Energy*, 2011, 88, (11), 4024–4032.

Wind energy has become a major competitor of traditional fossil fuel energy, particularly with the successful operation of multi-megawatt sized wind turbines. However, wind with reasonable speed is not adequately sustainable everywhere to build an economical wind farm. The potential site has to be thoroughly investigated at least with respect to wind speed profile and air density. Wind speed increases with height, thus an increase of the height of turbine rotor leads to more generated power. Therefore, it is imperative to have a precise knowledge of wind speed profiles in order to assess the potential for a wind farm site. This paper proposes a clustering algorithm based neuro-fuzzy method to find wind speed profile up to height of 100 m based on knowledge of wind speed at heights 10, 20, 30, 40 m. The model estimated wind speed at 40 m based on measured data at 10, 20, and 30 m has 3% mean absolute percentage error when compared with measured wind speed at height 40 m. This close agreement between estimated and measured wind speed at 40 m indicates the viability of the proposed method. The comparison with the 1/7th law and experimental wind shear method further proofs the suitability of the proposed method for generating wind speed profile based on knowledge of wind speed at lower heights.

12/01539 First order multivariate Markov chain model for generating annual weather data for Hong Kong

Yang, H. *et al. Energy and Buildings*, 2011, 43, (9), 2371–2377.

It has become popular to use computer simulation techniques to evaluate the performance of energy use in buildings. The hourly weather data as simulation input are a crucial factor for successful energy system simulation. To obtain an accurate set of weather data is necessary to represent the long-term typical weather conditions throughout a year. This paper introduces a stochastic approach, which is called the first-order multivariate Markov chain model, to generate the annual weather data for better evaluating and sizing different energy systems. The process for generating the weather data time series from the multivariate Markov transition probability matrices is described using 15 years of actual hourly weather data for Hong Kong. The ability of this new model for retaining the statistical properties of the generated weather data series is examined and compared with the current existing TMY and TRY data. The main statistical properties used for this purpose are mean value, standard deviation, maximum value, minimum value, frequency distribution probability and persistency probability of the weather data sequence. The comparison between the observed weather data and the synthetically generated ones shows that the statistical characteristics of the developed set of weather data are satisfactorily preserved and the developed set of weather data can predict and evaluate different energy systems more accurately.

12/01540 Forecasting building energy consumption using neural networks and hybrid neuro-fuzzy system: a comparative study

Li, K. *et al. Energy and Buildings*, 2011, 43, (10), 2893–2899.

As a regular data-driven method, artificial neural networks (ANNs) are popular in building energy prediction. In this paper, an alternative approach, namely, hybrid genetic algorithm-adaptive network-based fuzzy inference system (GA-ANFIS) is presented. In this model, GA optimizes the subtractive clustering's radiuses which help form the rule base, and ANFIS adjusts the premise and consequent parameters to optimize the forecasting performance. A hierarchical structure of ANFIS is also suggested to solve the probably curse-of-dimensionality problem. The performance of the proposed model is compared with ANN using two different data sets, which are collected from the energy prediction shootout I contest and a library building located in Zhejiang University, China. Results show that the hybrid GA-ANFIS model has better performance than ANN in term of prediction accuracy. The proposed model also has the same scale of modelling time as ANN if parameters in GA procedure are carefully selected. It can be regarded as an alternative method in building energy prediction.

12/01541 γ-CT measurement and CFD simulation of cross section gas holdup distribution in a gas–liquid stirred standard Rushton tank

Liu, Y.-J. *et al. Chemical Engineering Science*, 2011, 66, (17), 3721–3731.

Cross-section gas holdup distributions at 3/4 dimensionless static liquid height in a gas–liquid stirred standard Rushton tank were measured using ^{137}Cs γ-CT scan measuring technology at larger gas flow rates and higher impeller rotating speeds. The obtained CT scan images and digital distribution curves of gas holdup with dimensionless radius based on the CT images could explain the fluctuation changes of gas holdup distribution. The dense area of gas holdup distribution appeared in the upper space of impeller blades. Gas holdup increased both with gas flow rate and impeller rotating speed, but gas flow rate had more influence on gas holdup than impeller rotating speed. The Eulerian–Eulerian two-fluid model coupling with the bubbles' coalescence and break-up models, and the drag coefficient model were established to make CFD simulation of gas holdup distributions for the gas–liquid stirred Rushton tank under different gas flow rates and impeller rotating speeds.

12/01542 Gas solubilities in room temperature ionic liquids – correlation between RTiL-molar mass and Henry's law constant

Blath, J. *et al. Chemical Engineering Journal*, 2011, 172, (1), 167–176.

The solubility of CO_2, CH_4, N_2, and CO was measured in a broad number of ionic liquids using a pressure drop set-up. A successful correlation of the Henry's law constants at 60 °C was made to two empirical models already described in literature. Subsequently, a new empirical model was proposed, which describes the Henry's law constant as a function of the molar mass of the ionic liquid, as long as physical interactions between gas and ionic liquid are dominant. Additionally, the entropy and enthalpy of solvation was studied by means of the temperature influence to the Henry's law constant.

12/01543 Investigating the structure of non-graphitising carbons using electron energy loss spectroscopy in the transmission electron microscope

Zhang, Z.-l. *et al. Carbon*, 2011, 49, (15), 5049–5063.

This study investigated the structure and bonding in phenolic resin-based carbons as a function of heat treatment using a combination of high resolution transmission electron microscopy, electron energy loss spectroscopy, X-ray diffraction, gas adsorption and density measurements. On heat treatment, the initially amorphous material transforms to a micro-porous material containing small graphitic packets enclosing elongated pores, with a relatively small change in density but an appreciable change in planar carbon sp^2-content as well as the development of significant curvature in the graphitic layers. The results from the different characterization techniques are discussed and wherever possible, cross-correlated. They are also compared with proposed models for the microstructural development in non-graphitizing carbons and also with the corresponding data obtained from graphitizable carbons. Overall the data provides strong evidence for a fullerene-based model for the microstructural development in non-graphitizing carbons and more generally, the interpretation of the current EELS data has important implications for the spatially localized analysis of poorly crystalline carbon materials.

12/01544 Laboratory-scale ultrasound pre-treated digestion of sludge: heat and energy balance

Braguglia, C. M. *et al. Bioresource Technology*, 2011, 102, (16), 7567–7573.

The objective of this work was to maximize the digestibility of biological sludge to elucidate the feasibility of a new sludge management strategy to recover good quality sludge for agricultural use. The combined effects of organic loading rates (from 0.7 to 2.8 g VS L^{-1} d^{-1}) and the degree of disintegration by anaerobic digestion of sonicated activated sludge were discussed, and the thermal and energetic balances were evaluated. Despite low sonication inputs, sludge digestion performance improved in terms of solids degradation and biogas production depending on the soluble organic load. The biogas production by sonicated sludge was higher (up to 30%) with respect to the control. Filterability improved during digestion of sonicated sludge at medium OLR due to a significant abatement of the fines. Thermal balances indicated that sonication may be a proper system to guarantee self-sustaining WAS mesophilic digestion. Nevertheless, thickening is a pre-requisite to achieve a positive energy balance.

12/01545 Neutron and photon doses in high energy radiotherapy facilities and evaluation of shielding performance by Monte Carlo method

Ghassoun, J. *et al. Annals of Nuclear Energy*, 2011, 38, (10), 2163–2167.
Medical accelerators operating above 10 MV are a source of undesirable neutron radiations which contaminate the therapeutic photon beam. These photoneutrons can also generate secondary gamma rays which increases undesirable dose to the patient body and to personnel and general public. In this study, the Monte Carlo N-particle MCNP5 code has been used to model the radiotherapy room of a medical linear accelerator operating at 18 MV and to calculate the neutron and the secondary gamma ray energy spectra and the dose equivalents at various points inside the treatment room and along the maze. To validate the Monte Carlo simulation, the authors compared their results with those evaluated by the recommended analytical methods of IAEA Report No. 47, and with experimental and simulated values published in the literature. After validation, the Monte Carlo simulation has been used to evaluate the shielding performance of the radiotherapy room. The obtained results showed that the use of paraffin wax containing boron carbide, in the lining of the radiotherapy room walls, presents enough effectiveness to reduce both neutron and gamma ray doses inside the treatment room and at the maze entrance. Such evaluation cannot be performed by the analytical methods since room material and wall surface lining are not taken into consideration.

12/01546 New magic numbers in the continent of isotopes

Rydin, R. A. *Annals of Nuclear Energy*, 2011, 38, (11), 2356–2358.
Recently, it was explained that the magic numbers are really composites of several sub-shells filling, rather than being single shells. In addition, his theory leads to the conclusion that protons and neutrons fill sub-shells differently, because the protons tend to occupy outer shells first, while neutrons tend to occupy both outer and inner shells. Using a simple modification of Lucas' geometrical packing scheme, new magic proton and neutron numbers were postulated for the superheavy nuclei, which matched the island of stability distribution to a large extent. These magic numbers were also tested against some nuclei in the peninsula of isotopes, and found to be relevant. Now, in consideration of a suggestion made many years ago by Linus Pauling, new magic numbers between 50 and 82 are postulated in the continent of isotopes, and compared to experimental data. These new numbers have strong support among the three elements considered by Pauling, namely cadmium, tin and tellurium, and the results suggest that the range of isotopes found, their stability, and their lifetimes are strongly affected by the new magic numbers. In addition, if 58 nucleons are taken to be magic, then the double hump fission distribution for heavy isotopes may be explained semi-quantitatively.

12/01547 On quantum efficiency of nonideal solar cells

Brus, V. V. *Solar Energy*, 2012, 86, (2), 786–791.
A simple approach for the calculation of the width of the space charge region (and consequently the concentration of uncompensated acceptors), which takes into account the effect of the series resistance on the quantum efficiency of anisotype asymmetrical thin film heterojunction solar cells (on the example of CdS/CdTe solar cells), was proposed. The effect of the light dependent series resistance and current transport mechanism was also taken into consideration.

12/01548 On-line monitoring of the transesterification reaction between triglycerides and ethanol using near infrared spectroscopy combined with gas chromatography

Richard, R. *et al. Bioresource Technology*, 2011, 102, (12), 6702–6709.
Many analytical procedures have been developed to determine the composition of reaction mixtures during transesterification of vegetable oils with alcohols. However, despite their accuracy, these methods are time consuming and cannot be easily used for on-line monitoring. In this work, a fast analytical method was developed to on-line monitor the transesterification reaction of high oleic sunflower oil with ethanol using near-infrared spectroscopy and a multivariate approach. The reactions were monitored through sequential scans of the reaction medium with a probe in a one-litre batch reactor without collecting and preparing samples. To calibrate the NIR analytical method, gas chromatography-flame ionization detection was used as a reference method. The method was validated by studying the kinetics of the EtONa-catalysed transesterification reaction. Activation energy (51.0 kJ/mol) was also determined by considering a pseudo second order kinetics model.

12/01549 Rapid and precise estimation of biodiesel by high performance thin layer chromatography

Chattopadhyay, S. *et al. Applied Energy*, 2011, 88, (12), 5188–5192.
Various sophisticated chromatographic techniques using gas chromatography (GC) and high performance liquid chromatography (HPLC) were used to quantify biodiesel in terms of conversion percentage of the oil feedstock. These techniques are time consuming. In the present study, a rapid and reproducible technique was developed using high-performance thin-layer chromatography (HPTLC) for the accurate quantification of the conversion percentage of triglycerides into biodiesel (fatty acid methyl esters, FAME). The oil substrate was transesterified by a conventional process using alkali catalyst. The monoglycerides, diglycerides, unreacted triglycerides, free fatty acid and biodiesel (FAME) product were analysed by HPTLC. An absorption maximum of the mixture of standard methyl esters was determined to be 203.5 nm by spectroscopic scan. The conversion percentage was calculated from the corresponding peak areas of the glycerides and biodiesel product, separated on thin layer chromatography using hexane, ethyl acetate and acetic acid (9:1:0.1) as mobile phase. In terms of reproducibility and precision of data and also the ease and quickness of simultaneous processing, HPTLC-based analysis and quantification of biodiesel (FAME) proved to be an alternative to other conventional analytical techniques like GC and HPLC.

12/01550 Real system analyses/natural analogues

Noseck, U. *et al. Applied Geochemistry*, 2012, 27, (2), 490–500.
This paper gives an overview of the behaviour of U in two natural systems, the Forsmark site (a granitic system) in Sweden and the Ruprechtov site (a tertiary sedimentary system) in the Czech Republic, which have been investigated in the frame of the FUNMIG project. It is not a full review paper on U geochemistry. It shows how different approaches and methods have been used to derive information on U solubility and speciation, on characteristics of key processes as well as on timescales of these processes and accordingly information on the long-term stability of U phases in the natural systems. The results are set in a wider context by relation to selected results from other sites.

12/01551 Resonant Raman spectroscopy on enriched ^{13}C carbon nanotubes

Costa, S. D. *et al. Carbon*, 2011, 49, (14), 4719–4723.
Isotopically enriched single-wall carbon nanotubes with different ^{13}C concentrations were investigated by resonant Raman spectroscopy. Linear reductions of the Raman frequencies with an increase of ^{13}C concentration are observed for the different nanotube Raman modes, and the effect of the reduced mass variation of the isotope mixture on the phonon frequencies is described through a simple harmonic oscillator model. In addition to the frequency dependence, the Raman linewidths as a function of the ^{13}C concentration were also investigated and an expression describing this is presented. An increase in the G band linewidth was observed, as the ^{13}C:^{12}C ratio approached unity. Measurements with different excitation energies were performed and the frequency dispersions of the D and G′ bands with laser energy were observed to be the same for ^{12}C and ^{13}C nanotubes, suggesting no changes in the electronic structure after isotope enrichment. Through analysis of the radial breathing modes in the Raman spectra obtained with different excitation energies, a relation between these modes frequency and the ^{13}C nanotubes diameter was also established.

12/01552 Revisiting shrinking particle and product layer models for fluid–solid reactions – from ideal surfaces to real surfaces

Salmi, T. *et al. Chemical Engineering and Processing: Process Intensification*, 2011, 50, (10), 1076–1084.
A general model based on an arbitrary geometry was developed for reactive solid particles which have surface defects and porosity. The model equations comprising intrinsic kinetics as well as mass transfer effects through the product layer and the fluid film surrounding the solid particle were derived for shrinking particle and product layer models. From the model equations, the fluid (gas or liquid) concentrations at the reaction surface can be calculated and the change of the solid phase can be predicted. The approach was illustrated with monodisperse particle distributions in batch reactors. Complex kinetics as well as simpler special cases were treated. In general, the model predicts a higher reaction order with respect to the solid component than the previous ideal models, which assume slab, cylindrical or spherical geometries for solid particles.

12/01553 Structural decomposition analysis applied to energy and emissions: some methodological developments

Su, B. and Ang, B. W. *Energy Economics*, 2012, 34, (1), 177–188.

The only comprehensive study comparing structural decomposition analysis (SDA) and index decomposition analysis (IDA) was conducted around 2000. There have since been new developments in both techniques in energy and emission studies. These developments have been studied systematically for IDA but similar studies for SDA are lacking. In this paper, the authors aim to fill the gap by examining the new methodological developments in SDA. A new development is a shift towards using decomposition methods that are ideal. Four such SDA methods are compared analytically and empirically through decomposing changes in China's CO_2 emissions. The authors then provide guidelines on method selection and finally discuss the similarities and differences between SDA and IDA based on the latest available information.

12/01554 Study of the geometry of a voided clay brick using non-rectangular perforations to optimise its thermal properties

Morales, M. P. *et al. Energy and Buildings*, 2011, 43, (9), 2494–2498.

This study seeks to improve the geometrical distribution of bricks to optimize the equivalent thermal transmittance of a wall built of Termoarcilla® ECO 29 voided clay bricks, using calculations according to Spanish UNE, AENOR, European EN [0030], [0035], [0040] and [0045] and international ISO [0055] and [0060] standards. The objective is to study improvements in the wall's thermal conductivity, always remembering the limitations imposed by the manufacturing process. Simulations are made using a finite elements application. It is concluded that, within the possibilities allowed by the manufacturing process, with non-rectangular voids the heat flux has to cross a higher number of voids, which improves its thermal properties. A rhomboid layout of voids with the longer diagonal at right angles to the heat flux is the best internal void layout. If the internal perforations are also extended to the end of the tongue and groove, the direct thermal bridge in this type of brick is broken. Finally, a 290 mm wide brick with 25 rows is obtained with the geometrical properties described above which shows an improvement of almost 16% over the original ECO 29 brick, performing well in all climatic areas of Spain, with a full-bed mortar joint 30 mm thick.

12/01555 Study on temperature field around heat pipe underground based on line heat source theory

Gao, P. and Zhou, G. *Energy and Buildings*, 2011, 43, (9), 2483–2487.

Low and moderate geothermal resource can be found in most areas of the world and heat pump system as an efficient device to utilize the geothermal is prevalent. It is important to know temperature field around the heat-exchange pipelines for efficient conversion and use of geothermal energy. The temperature distribution around the heat pipe underground was studied by the heat source method in the paper. Based on the method, every heat pipe could be supposed as a heat source that would produce a corresponding temperature field, and the total temperature underground could be the superposition of every temperature- field. The temperature fields around heat pipes were given in the paper in different containing water rate of the soil, gap rate of the soil and different disposal of heat pipes. It would be beneficial for design and better operation of the heat pipe system underground to use geothermal resource.

12/01556 The scientometric evaluation of the research on the algae and bio-energy

Konur, O. *Applied Energy*, 2011, 88, (10), 3532–3540.

The present study explores the characteristics of the literature on the algae and bio-energy published during the last three decades, based on the database of Science Citation Index – Expanded (SCIE) and Social Sciences Citation Index (SSCI) and its implications using the scientometric techniques. The results of this work reveal that the literature on the algae and bio-energy has grown exponentially during this period reaching 717 papers in total. Most of document type is in the form of journal articles, reviews, and proceedings, constituting 98% of the total literature and English is the predominant language (97.6%). USA, China, Germany, and England are the four biggest contributing countries on the algae and bio-energy literature publishing, 26%, 8%, 8%, and 8% of the sample, respectively. The Chinese Academy of Sciences is the largest institutional contributor publishing 2.6% of the papers. The most publishing four authors are Wilhelm (13 papers) followed by Wu (15 papers), Mimuro (10 papers), and Zhao (nine papers). *Bioresource Technology* is the most publishing journal with 24 published papers, followed by *Journal of Applied Phycology* (17 papers), and *Biotechnology and Bioengineering* (15 papers). *Biotechnology & Applied Microbiology* is the subject area with 24.3% of the sample published. This is followed by *Energy & Fuels* (16.3%), *Marine & Freshwater Biology* (14.2%), and *Environmental Sciences* (12.3%). The total number of citations is 11,079, giving a ratio for the 'average citations per item' as 15.45 and 'H-index' as 52. A list of most-cited 25 authors is produced and Chisti (2007) receives 320 citations with 80 total average citations per year. This paper is followed by Lewis and Nocera (2006; 296 citations), Demirbas (2001; 187 citations). Chisti (2007) has the highest impact on the literature on the algae and energy with total average citations per year of 80. This is followed by Lewis and Nocera (2006, 59.8 annual citations) and Chisti (2008, 41 annual citations). An analysis of the citing papers shows the impact of the research on the algae and bio-energy for the related academic disciplines. This provides further incentives for all the stakeholders of the research on the algae and energy, but especially for the researchers and their institutions and their countries to do more research in this area. The results of this first ever such study of its kind show that the scientometric analysis has a great potential to gain valuable insights into the evolution of the research the on algae and bio-energy as in the case of new emerging technologies and processes such as nanoscience and nanotechnology complementing literature reviews, content analysis and meta-analysis research techniques.

12/01557 Three-dimensional neutronic calculations for a fusion breeder APEX reactor using some libraries

Günay, M. *et al. Annals of Nuclear Energy*, 2011, 38, (12), 2757–2761.

The effects of evaluated nuclear data files on neutronics characteristics of a fusion–fission hybrid reactor have been analysed; three-dimensional calculations have been made using the MCNP4C Monte Carlo Code for ENDF/B-VII $T = 300$ K, JEFF-3.0 $T = 300$ K, and CENDL-2 $T = 300$ K evaluated nuclear data files. The nuclear parameters of a fusion–fission hybrid reactor such as tritium breeding ratio, energy multiplication factor, fissile fuel breeding and nuclear heating in a first wall, blanket and shield have been investigated for the mixture components of 90% Flibe (Li_2BeF_4) and 10% UF_4 for a blanket layer thickness of 50 cm. The contributions of each isotope of Flibe (^{6}Li, ^{7}Li, ^{19}F, ^{9}Be) and UF_4 (^{235}U, ^{238}U) to the integrated parameter values were calculated. The neutron wall load is assumed to be 10 MW/m^2.

Fuel cell technology

12/01558 A microfluidic microbial fuel cell fabricated by soft lithography

Qian, F. *et al. Bioresource Technology*, 2011, 102, (10), 5836–5840.

A new microfluidic microbial fuel cell (MFC) platform built by soft-lithography techniques is considered. The MFC design includes a unique sub-5 μL polydimethylsiloxane soft chamber featuring carbon cloth electrodes and microfluidic delivery of electrolytes. Bioelectricity was generated using *Shewanella oneidensis* MR-1 cultivated on either complex organic substrates or lactate-based minimal medium. These micro-MFCs exhibited fast start-ups, reproducible current generation, and enhanced power densities up to 62.5 W m^{-3} that represents the best result for sub-100 μL MFCs. Systematic comparisons of custom-made MFC reactors having different chamber sizes indicate volumetric power density is inversely correlated with chamber size in these systems. That is, the smaller the chamber, the higher the power density is achieved.

12/01559 Anode modification by electrochemical oxidation: a new practical method to improve the performance of microbial fuel cells

Zhou, M. *et al. Biochemical Engineering Journal*, 2012, 60, 151–155.

Electrochemical oxidation as a convenient and effective method was established for anode modification to improve the performance of microbial fuel cells (MFCs). The anode modification was realized by one-step electrochemical treatment in one of the three electrolytes (nitric acid, ammonium nitrate, ammonium persulfate) at ambient temperature. The performances of MFCs before and after anode modification were compared, confirming that all these anode modifications posed positive effects. The maximum power density of the MFC with the anode modified by nitric acid was 792 mW/m^2, which was 43% larger than the unmodified control (552 mW/m^2). Furthermore, the Coulombic efficiency (CE) significantly promoted about 71% from 14% (the unmodified MFC) to 24%. It revealed that the electrochemical oxidation resulted in the change of the anode properties, such as surface morphology, internal resistance and anode potential, and thus benefited to the microbial attachment and electron transfer on the anode surface, which might contribute to the performance improvement of the MFCs.

12/01560 Assessing porosity of proton exchange membrane fuel cell gas diffusion layers by scanning electron microscope image analysis

Farmer, J. *et al. Journal of Power Sources*, 2012, 197, 1–11.

A gas diffusion layer (GDL) in a proton exchange membrane fuel cell may consist of several, materials of different porosities, with each material serving a specific set of functions. For example, samples analysed in this work consisted of a macro porous carbon paper substrate treated with a, hydrophobic wet proofing material in differing amounts, which was then coupled to a micro porous, layer. The porosities of four such GDLs were determined by using 2D scanning electron microscope (SEM) images to mathematically model the volumes filled by each solid in the 3D structures. Results, were then compared with mercury intrusion porosimetry (MIP) measurements to verify the accuracy, of the method. It was found that the use of SEM not only allowed for detailed porosity analysis of, separate porous materials within the GDL, but also porosity for the entire GDL could be calculated for, the seemingly complex structures with reasonable accuracy. With some basic geometric assumptions, and use of the superposition principle, the calculated results were accurate to less than a 2% absolute, difference of the porosity measured by MIP for each of the four samples analysed.

12/01561 CH_4 decomposition on Ni and Co thin layer catalysts to produce H_2 for fuel cell

Frusteri, F. *et al. Catalysis Today*, 2011, 171, (1), 60–66.

Ni and Co supported on SiO_2 and Al_2O_3 silica cloth thin layer catalysts (TLC) were investigated in the catalytic decomposition of natural gas (CDNG) reaction using a multilayer catalytic reactor (MCR). The influence of support and reaction temperature was evaluated with the aim to design a novel catalyst suitable to develop a dual-step process to produce pure hydrogen for fuel cell. Ni and Co silica supported catalyst, due to the low metal supported interaction (MSI) characterizing such systems, were not found suitable to efficiently perform CDNG reaction. On the contrary in case alumina was used as support both metals strongly interact with surface becoming so more resistant to sintering. In addition in case the metals (both Ni and Co) strongly interact with support surface, the formation of encapsulating carbon is depressed and only filamentous carbon forms. Using Ni and Co TLC supported on Al_2O_3 samples it has been possible to realize a cyclic dual-step process based on reaction and regeneration in oxygen stream without any catalyst detriment. A deactivation modelling to discriminate the role of sintering and coking on the deactivation pattern is proposed.

12/01562 Design improvement of circular molten carbonate fuel cell stack through CFD analysis

Verda, V. and Sciacovelli, A. *Applied Thermal Engineering*, 2011, 31, (14–15), 2740–2748.

Molten carbonate fuel cell (MCFC) is a promising technology for distributed power generation. The core of an MCFC power generation unit is the stack, where various fuel cells are connected together in series and parallel in order to obtain the desired voltage and power. Stack geometry and configuration are major engineering topics, as inhomogeneous temperature or mass fractions cause inefficient performances of the fuel cells, as efficiency and power smaller than the expected and shorter lifetime. A detailed model is a useful tool to improve stack performances, through design improvements. In this paper, a 3D model of a stack composed of 15 circular MCFC, considering heat, mass and current transfer as well as chemical and electrochemical reactions is presented. The model validation is conducted using some preliminary experimental data obtained for an MCFC stack developed in the Fabbricazioni Nucleari laboratories. These results are examined in order to improve the stack configuration. It is shown that power density may be increased of about 20% through double side feeding. In addition, the average temperature gradients in the axial direction are reduced of more than 70%. Significant reductions in the temperature gradients, especially in transversal direction, can be achieved by adjusting the mass flow rate of cathodic gas supplied to the various cells.

12/01563 Efficiency analyses of ethanol-fueled solid oxide fuel cell power system

Hong, W.-T. *et al. Applied Energy*, 2011, 88, (11), 3990–3998.

In this study, the balance of plant (BOP) of an ethanol-fuelled SOFC is analysed using the GCTool software package developed by Argonne National Laboratory (ANL). The effects of the excess air ratio and fuel utilization on the electric and heat efficiencies of the SOFC are systematically examined for two reforming methods (steam reforming and auto-thermal reforming) and two flow sheets (BOP A and BOP B). In BOP A, the cathode off-gas is passed directly to the afterburner together with the unreacted fuel, and the hot flue gas exiting the burner is then used to provide the thermal energy required for the ethanol reforming process. In BOP B, the cathode off-gas is passed through a heat exchanger in order to heat the ethanol fuel prior to the reforming process, and is then flowed into the burner with the unreacted fuel. The results show that given an SOFC inlet temperature of 650 °C, a fuel utilization of 70.2% and excess air ratios of 4, 6 and 7, respectively, the overall system efficiency is equal to 74.9%, 72.3% and 71.0%. In general, the results presented in this study provide a useful starting point for the design and development of practical ethanol-fuelled SOFC test systems.

12/01564 Enhanced anaerobic degradation of organic pollutants in a soil microbial fuel cell

Huang, D.-Y. *et al. Chemical Engineering Journal*, 2011, 172, (2–3), 647–653.

The anaerobic degradation of organic pollutants is generally slower than under aerobic conditions. With the aim of *in situ* remediation of anoxic soils contaminated with organic pollutants, an insertion-type soil microbial fuel cell (MFC) was constructed and inserted into waterlogged soil to enhance the biodegradation of phenol and simultaneously electricity generation. The highest power density reached $29.45\,mW/m^2$, and an internal resistance of approximately $140\,\Omega$ was obtained under an external loading of $100\,\Omega$. Under closed-circuit conditions, 90.1% of the phenol was removed after the soil MFC had operated for 10 days, but the degradation rates were only 27.6% and 12.3% under open-circuit and non-MFC conditions, respectively. The phenol degradation rate constant (k) under closed-circuit conditions was 0.390/day, which was approximately 23 times higher than under non-MFC conditions. The degradation of phenol was also positively correlated with the removal of soluble COD and particulate COD, indicating that the removal of organic pollutants and COD in waterlogged soils could be enhanced by a soil MFC system coupled with electricity generation. This method has important implications for soil remediation because it may accelerate the transformation or degradation of some toxic organic pollutants under anoxic conditions.

12/01565 Gas turbine performance at varying ambient temperature

De Sa, A. and Al Zubaidy, S. *Applied Thermal Engineering*, 2011, 31, (14–15), 2735–2739.

The difference between the actual power generated by a gas turbine and the design rated power tagged on the gas turbine is observed whenever a gas turbine operates at site ambient conditions that vary from the stipulated ISO conditions. A detailed study and extensive logging of data has endorsed the well-known existence of a direct relationship between the ambient temperature and the de-rating of gas turbine power output. The paper proposes an empirical relationship between the gas turbine's ability to generate power when exposed to site ambient conditions, such as the ambient temperature, which differ from ISO conditions. For every K rise in ambient temperature above ISO conditions the gas turbine loses 0.1% in terms of thermal efficiency and 1.47 MW of its gross (useful) power output. This established relationship will assist the proper assessment of local power generation for installation planning and forecasting with special reference to Middle-eastern countries which are rapidly developing the application of gas turbine inlet air cooling (GTIAC) technologies. This study was conducted for specific turbines SGT 94.2 and SGT 94.3 installed at the DEWA power station located at Al Aweer, H Phase II and III in Dubai, UAE.

12/01566 Microbial fuel cell enables phosphate recovery from digested sewage sludge as struvite

Fischer, F. *et al. Bioresource Technology*, 2011, 102, (10), 5824–5830.

Orthophosphate was mobilized from iron phosphate ($FePO_4$) contained in digested sewage sludge by microbial fuel cell power. $FePO_4$ was reduced through electrons and protons obtained from metabolic activity of *Escherichia coli*. The process yielded up to 82% or 600 mg/l. Optical emission spectroscopy was used for phosphate dosage. ^{31}P NMR showed a singlet at $\delta_P = 3.72\,ppm$ indicating that orthophosphate (H_3PO_4, HPO_4^-, HPO_4^{2-} and PO_4^{3-}) was recovered. The phosphate containing supernatant solution was reacted with stoichiometric amounts of $MgCl_2$ and NH_4OH to precipitate struvite ($MgNH_4PO_4{\cdot}6H_2O$). The crystalline fertilizer was analysed by scanning electron microscopy comprising elemental analysis, revealing a composition accuracy of $\sim$90% and the absence of any toxic metals such as As, Cd, Pb, or Cr. The phosphate extraction is also a means to reduce the volume of digested sewage sludge while increasing the heat of combustion. This study represents a concept for sustainable decentralized phosphate recycling.

12/01567 Performance comparison between partial oxidation and methane steam reforming processes for solid oxide fuel cell (SOFC) micro combined heat and power (CHP) system

Liso, V. *et al. Energy*, 2011, 36, (7), 4216–4226.

The aim of this research work is to describe in qualitative and quantitative form the performance of a micro combined heat and power system for residential application based on solid oxide fuel cell fuelled by natural gas with two different types of pre-reforming systems, namely steam reforming and partial oxidation and recirculation of anode and cathode gas. The comparative analysis among the different configurations will lead us to conclude that maximum efficiency is achieved when cathode and anode gas recirculation are used along with steam methane reforming. Further steam methane reforming process produces a higher electrical system efficiency compared to Partial oxidation reforming process. Efficiency is affected when running the system in part load mode mainly due to heat loss, additional natural gas supplied to the burner to satisfy the required heat demand inside the system, and ejector efficiency drop in the recirculation system. Due to high temperature of operation heat loss strongly affects the system efficiency especially at part load operation.

12/01568 Performance of proton exchange membrane fuel cells at elevated temperature

Shyu, J.-C. *et al. Energy Conversion and Management*, 2011, 52, (12), 3415–3424.

The polarization curves of a single PEMFC having a Nafion membrane fed with H_2/O_2 with relative humidity (RH) of 35%, 70% and 100% were measured at cell temperatures ranging from 65 °C to 120 °C at back pressures of 0 atm and 1 atm, respectively. Measured results showed that the best cell performance at 0.6 V operated within 65–120 °C at zero back pressure was $1000\,\mathrm{mA\,cm^{-2}}$ at 65 °C and RH = 100%, while the best cell performance at 1 atm back pressure was $1300\,\mathrm{mA\,cm^{-2}}$ at 100 °C and RH = 100%. Based on the analysis of impedance data measured at anode and cathode humidification temperatures of 90 °C and cell temperature of 100 °C at back pressures of 0 and 1 atm (90–100p0 and 90–100p1), it could be found that the membrane resistance was reduced and the catalyst became more active as the back pressure increases. The present results showed that increasing back pressure was able to dramatically improve cell performance and the effect of the back pressure surpassed that of humidification in the internal resistance of cell.

15 ENVIRONMENT

Pollution, health protection, applications

12/01569 Approach to the evaluation of the thermal work environment in the greenhouse-construction industry of SE Spain

Pérez-Alonso, J. *et al. Building and Environment*, 2011, 46, (8), 1725–1734.

The aim of the present work was to evaluate the thermal environment of workers in the greenhouse-construction industry in south-eastern Spain. For this, the heat stress of these workers was evaluated by the WBGT index, on developing quadratic equations of the maximum and minimum of this index according to the time of day. High correlation coefficients and good distributions of residuals were found. This evaluation revealed a high or very high risk of heat stress during the months of June to September over a large part of the work day, especially from 9:00 to 18:00 h. For this, work-rest regimes are proposed in order to control this risk. Finally, the application of the ESI index has been validated for determining the heat stress in greenhouse-construction workers in south-eastern Spain.

12/01570 Behavioural patterns and user profiles related to energy consumption for heating

Santin, O. G. *Energy and Buildings*, 2011, 43, (10), 2662–2672.

The difference between the actual and predicted energy consumption for heating in housing is thought to be partly attributable to the use of HVAC systems. More reliable data on energy consumption could help in determining the actual energy performance of dwellings and in the search for the most adequate design for housing and home amenities. Further reductions on energy consumption might also be achieved if energy-saving policy programmes were geared to different household groups. The aim of this paper is to statistically determine behavioural patterns associated with the energy spent on heating and to identify household and building characteristics that could contribute to the development of energy-user profiles. This study had two outcomes: it identified behavioural patterns to be used in energy calculations and it discerned user profiles with different behaviours. Five underlying groups of behavioural variables were found, which were used to define the behavioural patterns and user profiles. The groups showed statistically significant differences in the scores for most of the behavioural factors. This study established clear relationships between occupant behaviour and household characteristics. However, it seems difficult to establish relationships between energy consumption and behavioural patterns and household groups.

12/01571 Biogas generation from sewage in four public universities in Ghana: a solution to potential health risk

Arthur, R. *et al. Biomass and Bioenergy*, 2011, 35, (7), 3086–3093.

Apart from waste treatment, anaerobic digestion is a reliable method for biogas generation. The digested sludge from anaerobic digesters can also be used to enhance the fertility of the soil. This paper assesses the biogas potential from the sewage generated in four public universities in Ghana for the 2008/2009 academic year. In the estimation of the amount of sewage generated in each university, the population was used and was categorized into residential and non-residential staff and students. The population of the universities varies throughout the year due to the vacation periods hence the sewage generated varies accordingly. The estimated population for the four universities was 100,313 when in session and 20,903 on vacation and the estimated daily sewage generated is $1379.9\,\mathrm{m^3}$ and $327.8\,\mathrm{m^3}$, when the universities were in session and on vacation respectively. This study revealed that an annual biogas potential of about $815{,}109\,\mathrm{m^3}$ could be obtained which is equivalent to about 4,891 MWh of energy or can replace about 4532 tonnes of firewood or 326.4 tonnes of LPG which can reduce the pressure on the forest and the use of LPG.

12/01572 Biophysical properties and thermal performance of an intensive green roof

Jim, C. Y. and Tsang, S. W. *Building and Environment*, 2011, 46, (6), 1263–1274.

Green roofs have been increasingly enlisted to alleviate urban environmental problems associated with urban heat island effect and stormwater quantity and quality. Most studies focus on extensive green roofs, with inadequate assessment of the complex intensive type, subtropical region, and thermal insulation effect. This study examines the physical properties, biological processes, and thermal insulation performance of an intensive green roof through four seasons. An experimental woodland installed on a Hong Kong building rooftop was equipped with environmental sensors to monitor microclimatic and soil parameters. The excellent thermal performance of the intensive green roof is verified. Even though the site has a 100 cm thick soil to support tree growth, it was found that a thin soil layer of 10 cm is sufficient to reduce heat penetration into building. Seasonal weather variations notably control transpiration and associated cooling effect. The tree canopy reduces solar radiation reaching the soil surface, but the trapped air increases air temperature near the soil surface. The substrate operates an effective heat sink to dampen temperature fluctuations. In winter, the subtropical green roof triggers notable heat loss from the substrate into the ambient air, and draws heat upwards from warmer indoor air to increase energy consumption to warm indoor air. This finding deviates from temperate latitude studies. The results offer hints to optimize the design and thermal performance of intensive green roofs.

12/01573 Consumer willingness to pay for appliances produced by Green Power Partners

Ward, D. O. *et al. Energy Economics*, 2011, 33, (6), 1095–1102.

The US Environmental Protection Agency's Green Power Partnership (GPP), has over 1200 members purchasing nearly 18 billion kilowatt hours of green power annually. One possible motivation for firms to join the GPP is to raise their reputation for environmental quality among consumers. This research investigates the extent to which consumer preferences for a residential appliance are affected by information on whether or not the appliance manufacturer was a member of the GPP. Data for the study were obtained from a contingent choice exercise in an online survey of a national sample of adults. The results suggest that consumers are, on average, willing to pay an extra \$48.52 to \$70.95 for a refrigerator manufactured by a company that is a member of the GPP. These amounts appear to generally exceed the additional costs associated with using green power to manufacture a refrigerator and suggest that GPP could effectively be used to market consumer products.

12/01574 Ecological energetics of tropical intensive green roof

Jim, C. Y. and Tsang, S. W. *Energy and Buildings*, 2011, 43, (10), 2696–2704.

Few green roof studies cover intensive and tropical types and specific canopy microclimate. The authors examined the ecological energetics of a sky woodland in humid, tropical Hong Kong. Environmental sensors monitored the microclimatic and soil parameters for 14 months. Key biophysical variables of transpiration, wind, light, and through-canopy energy flux are modelled to investigate seasonal and weather effects. The woodland forms a cloistered sub-canopy environment with rather stable microclimate. Transpiration and latent heat loss are enhanced by solar radiation and low relative humidity, but less by wind. On sunny days, about 20% of incident solar radiation can reach the soil surface. The canopy reflected more near-infrared radiation than photosynthetically active radiation, highlighting a hitherto neglected passive-cooling mechanism. The highest transpiration rate occurs in autumn rather than summer due to dry-mild weather. The woodland canopy could reduce 300 W m^{-2} energy flux into the substrate. The canopy warmed by solar energy transmits heat to sub-canopy air. Latent and sensible heat loss in the sub-canopy domain is suppressed, thus dampening the passive-cooling effect. The capability of the tropical intensive green roof to reduce temperature is relatively inefficient comparing with temperate region counterparts. The findings could inform design and choice of green roofs.

12/01575 Economic prospects of ocean iron fertilization in an international carbon market

Rickels, W. *et al. Resource and Energy Economics*, 2012, 34, (1), 129–150.

Staying within the 2 °C temperature increase target for climate change requires for ambitious emission reduction targets for the 2012–2020 compliance period. Cost-efficiency is a crucial criterion for the achievement of such targets, requiring analyses of all possible options. Enhancing the oceanic carbon sink via ocean iron fertilization (OIF) provides such an option. The analysis reveals that the critical unit costs per net ton of CO_2 sequestered by OIF range from US$22 to 28 (price level 2000) in a post-Kyoto compliance scenario. The critical unit costs are defined as those that would make an emitter indifferent between various abatement options. With reference to hypothetical short-term large-scale Southern Ocean OIF the authors are able to show that 7 years of OIF provide a number of credits exceeding those obtainable from global forestation projects lasting 20 years. From an economic perspective, the results indicate that OIF can be considered a potentially viable carbon-removal option. However, further research is needed, especially on adverse side-effects and their ecological and economic consequences.

12/01576 Effect of real-time boundary wind conditions on the air flow and pollutant dispersion in an urban street canyon – large eddy simulations

Zhang, Y.-W. *et al. Atmospheric Environment*, 2011, 45, (20), 3352–3359.

Air flow and pollutant dispersion characteristics in an urban street canyon are studied under the real-time boundary conditions. A new scheme for realizing real-time boundary conditions in simulations is proposed, to keep the upper boundary wind conditions consistent with the measured time series of wind data. The air flow structure and its evolution under real-time boundary wind conditions are simulated by using this new scheme. The induced effect of time series of ambient wind conditions on the flow structures inside and above the street canyon is investigated. The flow shows an obvious intermittent feature in the street canyon and the flapping of the shear layer forms near the roof layer under real-time wind conditions, resulting in the expansion or compression of the air mass in the canyon. The simulations of pollutant dispersion show that the pollutants inside and above the street canyon are transported by different dispersion mechanisms, relying on the time series of air flow structures. Large scale air movements in the processes of the air mass expansion or compression in the canyon exhibit obvious effects on pollutant dispersion. The simulations of pollutant dispersion also show that the transport of pollutants from the canyon to the upper air flow is dominated by the shear layer turbulence near the roof level and the expansion or compression of the air mass in street canyon under real-time boundary wind conditions. Especially, the expansion of the air mass, which features the large scale air movement of the air mass, makes more contribution to the pollutant dispersion in this study. Comparisons of simulated results under different boundary wind conditions indicate that real-time boundary wind conditions produces better condition for pollutant dispersion than the artificially-designed steady boundary wind conditions.

12/01577 Effects of carbonaceous nanoparticles from low-emission and older diesel engines on human skin cells

Fiorito, S. *et al. Carbon*, 2011, 49, (15), 5038–5048.

Diesel exhaust particles (DEP) are major constituents of ambient air pollution and are associated with respiratory and cardiovascular diseases as well skin cell alterations *in vitro*. The epidermal cells are among the first cell populations exposed to chemical pollutants, including DEP, and are an important source of pro-inflammatory mediators. The authors evaluated the effects of carbonaceous soot particles from current low-emission (Euro IV) diesel engines on the oxidative and inflammatory response of normal human skin cells and compared the results with those induced by carbonaceous soot particles from an older diesel engine (BS) operating under black smoke conditions. Both soot nanoparticles were spontaneously internalized by keratinocytes and distributed mostly around the cell nucleus. Moreover, at the same mass concentration, Euro IV soot particles exhibited a much higher oxidative, pro-fibrotic and toxic potential on these cell types than soot particles from the older diesel engine. These results are in agreement with and confirm the previous findings on human macrophage cells and strengthen the assumption that, at the same mass concentration, soot particles produced under low emission conditions are more cytotoxic than particles from the older diesel engine. This effect could be assigned to the defective surface structure of Euro IV diesel soot, rendering it highly active. These findings highlight that the reduction of soot emission in terms of mass does not automatically lead to a reduction of the dangerous effects and show that soot particles from different diesel engines possess different biological behaviour towards human cells.

12/01578 Effects of climate change on biomass production and substitution in north-central Sweden

Poudel, B. C. *et al. Biomass and Bioenergy*, 2011, 35, (10), 4340–4355.

In this study the effects of climate change on forest production in north-central Sweden are estimated, as well as the potential climate change mitigation feedback effects of the resulting increased carbon stock and forest product use. The results show that an average regional temperature rise of 4 °C over the next 100 years may increase annual forest production by 33% and potential annual harvest by 32%, compared to a reference case without climate change. This increased biomass production, if used to substitute fossil fuels and energy-intensive materials, can result in a significant net carbon emission reduction. It is found that carbon stock in forest biomass, forest soils, and wood products also increase, but this effect is less significant than biomass substitution. A total net reduction in carbon emissions of up to 104 Tg of carbon can occur over 100 years, depending on harvest level and reference fossil fuel.

12/01579 Evaluation of the GreenBuilding Programme

Valentová, M. and Bertoldi, P. *Energy and Buildings*, 2011, 43, (8), 1875–1883.

In early 2006 the European Commission launched the GreenBuilding Programme (GBP), aimed at improving the energy efficiency of existing as well as newly constructed non-residential buildings in Europe on a voluntary basis. Building owners from different sectors are participating in the programme, e.g. public authorities with schools, hospitals or swimming pools, companies from the services and industry sectors with office buildings, sports centres and hotels. The aim of the paper is to provide a summary analysis of the results of the GBP over its almost 4-year operation – from the launch of the programme in 2006 until the end of 2009. By the end of 2009, 167 partners had joined the programme with almost 300 buildings from all sorts of fields and sectors of operation. The total savings achieved by the Partners are 304 GWh/year. The buildings themselves may vary in age, size and use, but they all have in common the energy performance, which goes far beyond the average performance of buildings in the participating countries. The paper focuses on efficiency measures implemented in the participating buildings and the achieved energy savings.

12/01580 Factors influencing future oil and gas prospects in the Arctic

Harsem, Ø. *et al. Energy Policy*, 2011, 39, (12), 8037–8045.

The article explores oil and natural gas development in the Arctic. While several commentators have argued that an increase in Arctic petroleum production in the years to come will follow directly from an increased demand for energy, the study finds that oil and natural gas production in the Arctic is dependent on a range of variables. By using climate-driven changes as a baseline, the authors examine spill-over effects and conditions that are important for further Arctic hydrocarbon production. Using the available literature from different scientific fields, this article provides a broad and nuanced perspective on the much debated question of whether or not the Arctic will become a region driven by oil and gas production.

12/01581 Heat and cold stresses in different climate zones across China: a comparison between the 20th and 21st centuries

Li, D. H. W. *et al. Building and Environment*, 2011, 46, (8), 1649–1656.

Summer and winter discomfort in terms of heat and cold stresses in the nine major architectural climate zones and sub-zones across China in the twenty-first century were investigated using predictions from general circulation models for the low and medium emissions scenarios. For the six severe cold and cold climate zones in the north, reductions in cumulative cold stress outweighed the increase in cumulative heat stress resulting in an overall decreasing trend in the annual cumulative stress, and vice versa for the other three warmer climate zones in the south. Compared with the twentieth century, significant reduction in the cumulative cold stress was observed across the six zones in severe cold and cold climates, ranging from 15.8 in cold-III to 42.3 in severe cold-II. There were modest increases in the cumulative heat stress from 0.3 in cold-II to 12.3 in cold-III. For the warmer climates in the south, reduction in cumulative cold stress ranged from 7.6 in hot summer and warm winter (HSWW) to 10.3 in hot summer and cold winter, while cumulative heat stress increased from 9.9 in the mild zone to 30.6 in HSWW. A reduction in cold stress would result in less winter heating and an increase in heat stress more cooling requirement.

12/01582 How to ensure greenhouse gas emission reductions by increasing the use of biofuels? – Suitability of the European Union sustainability criteria

Soimakallio, S. and Koponen, K. *Biomass and Bioenergy*, 2011, 35, (8), 3504–3513.

Biofuels are promoted in many parts of the world. However, concern of environmental and social problems have grown due to increased production of biofuels. Therefore, many initiatives for sustainability criteria have been announced. As a part of the European Union (EU) renewable energy promotion directive (RED), the EU has introduced greenhouse gas (GHG) emission-saving requirements for biofuels along with the first-ever mandate methodology to calculate the GHG emission reduction. As explored in this paper, the RED methodology, based on life-cycle assessment (LCA) approach, excludes many critical issues. These include indirect impacts due to competition for land, biomass and other auxiliary inputs. Also, timing issues, allocation problems, and uncertainty of individual parameters are not yet considered adequately. Moreover, the default values provided in the RED for the GHG balances of biofuels may significantly underestimate their actual impacts. It is concluded that the RED methodology cannot ensure the intended GHG emission reductions of biofuels. Instead, a more comprehensive approach is required along with additional data and indicators. Even if it may be very difficult to verify the GHG emission reductions of biofuels in practice, it is necessary to consider the uncertainties more closely, in order to mitigate climate change effectively.

12/01583 Impact of adaptive thermal comfort criteria on building energy use and cooling equipment size using a multi-objective optimization scheme

Hamdy, M. *et al. Energy and Buildings*, 2011, 43, (9), 2055–2067.

Recently adaptive thermal-comfort criteria have been introduced in the international indoor-climate standards to reduce the heating/cooling energy requirements. In 2008, the Finnish Society of Indoor Air Quality (FiSIAQ) developed the national adaptive thermal-comfort criteria of Finland. The current study evaluates the impact of the Finnish Criteria on energy performance in an office building. Two fully mechanically air-conditioned single offices are taken as representative zones. A simulation-based optimization scheme (a combination of IDA-ICE 4.0 and a multi-objective genetic-algorithm from MATLAB-2008a) is employed to determine the minimum primary energy use and the minimum room cooling-equipment size required for different thermal comfort levels. The applicability of implementing energy-saving measures such as night ventilation, night set-back temperature, day lighting as well as optimal building envelope and optimal HVAC settings are addressed by investigating 24 design variables. The results show that, on average, an additional 10 kWh/(m^2 a) primary energy demand and a larger 10 W/m^2 room cooling-equipment size are required to improve the thermal comfort from medium (*S*2) to high-quality (*S*1) class; higher thermal comfort levels limit the use of night ventilation and water radiator night-set back options. Compared with the ISO EN 7730–2005 standard, the Finnish criterion could slightly decrease the heating/cooling equipment size. However, it significantly increases both the heating and cooling energy demand; the results show 32.8% increase in the primary energy demand. It is concluded that the Finnish criterion-2008 is strict and does not allow for energy-efficient solutions in standard office buildings.

12/01584 Integral indicator of ecological impact of the Croatian thermal power plants

Strijov, V. *et al. Energy*, 2011, 36, (7), 4144–4149.

The main goal of this paper is to present the methodology of construction of the integral indicator for the Croatian thermal power plants and the combined heat and power plants. The integral indicator is intended to compare the power plants according to a certain criterion. The criterion of the ecological impact is chosen. The following features of the power plants are used: generated electricity and heat; consumed coal and liquid fuel; sulfur content in fuel; emitted CO_2, SO_2, NO_x, and particles. The linear model is used to construct the integral indicator. The model parameters are defined by the principal component analysis. The constructed integral indicator is compared with several others, such as Pareto-optimal slicing indicator and metric indicator. The integral indicator keeps as much information about the waste measures of the power plants as possible; it is simple and robust.

12/01585 Land-based mitigation in climate stabilization

Rose, S. K. *et al. Energy Economics*, 2012, 34, (1), 365–380.

This paper evaluates the role of land in long-run climate stabilization mitigation scenarios. The details of land modelling for common stabilization policy scenarios are, for the first time, presented, contrasted, and assessed. While significant differences in approaches are found across modelling platforms, all the approaches conclude that land-based mitigation – agriculture, forestry, and biomass liquid and solid energy substitutes – could be a steady and significant part of the cost-effective portfolio of mitigation strategies; thereby, reducing stabilization cost and increasing flexibility for achieving more aggressive climate targets. However, large fossil fuel emissions reductions are still required, and there are substantial uncertainties, with little agreement about abatement magnitudes. Across the scenarios, land mitigation options contribute approximately 100–340 GtC equivalent abatement over the century, 15–40% of the total required for stabilization, with bio-energy providing up to 15% of total primary energy. Long-run land climate modelling is rapidly evolving with critical challenges to address. In characterizing current capability, this paper hopes to stimulate future research and the next generation of land modelling and provide a point of comparison for energy and climate policies considering bio-energy, reduced deforestation and degradation, and cost containment.

12/01586 Measurements of occupancy levels in multi-family dwellings – application to demand controlled ventilation

Johansson, D. *et al. Energy and Buildings*, 2011, 43, (9), 2449–2455.

The occupancy level of dwellings is an important parameter to know to determine the energy efficiency, energy use and indoor air quality, especially in low-energy buildings where the user-related energy uses, such as household electricity and domestic hot water heating, are significant parts of the energy balance in a building. For residential buildings, there is a lack of occupancy level data, which also needs to be resolved over time, in a way so that both short term and long term variations can be described. As a part of an on-going study, occupancy levels were measured as building average levels in 18 apartment buildings containing 342 apartments in total with readings every 30 min for more than a year. Averages and standard deviations of occupancy level, and variation in occupancy during the year, week and day respectively are presented. The results show a highly varying occupancy level over time, which indicates the potential of demand controlled ventilation in dwellings.

12/01587 Potential threat of heavy metals in re-suspended dusts on building surfaces in oilfield city

Kong, S. *et al. Atmospheric Environment*, 2011, 45, (25), 4192–4204.

30 re-suspended dust samples were collected from building surfaces of an oilfield city, then re-suspended through $PM_{2.5}$, PM_{10} and PM_{100} inlets and analysed for 10 metals including V, Cr, Mn, Co, Ni, Cu, Zn, As, Cd and Pb by inductively coupled plasma-mass spectroscopy. Metals concentrations in different fractions and locations were studied. Metals sources were identified by cluster and primary component analysis. The potential risk to human health was assessed by human exposure model. Results showed that Zn, Mn, Pb and Cu were higher in all the three fractions. V, Cr, Mn and Co ranged close to the background values of Chinese soil indicating that they were mainly from crustal materials. Concentrations of Zn, Mn, Pb, V, Cr, Ni, Co and Cd were higher in old district than that in new district for the three fractions. The $PM_{2.5}/PM_{10}$, PM_{10}/PM_{100} and $PM_{2.5}/PM_{100}$ ratios were higher for Zn, Cd, Cu, Pb, Ni, As and Cr (all higher than 1.0), and lower for Co, Mn and V (all less than or close to 1.0) which meant that anthropologic sources associated metals were more easily accumulated in finer particles than metals from crustal materials. Spatial variations indicated that the 10 metals peaked at surroundings near railway station, gas stations, industrial boilers and machine manufacturing plant implying the influence of local vehicle emission, fossil fuel combustion and industrial activities as well as crustal materials which was verified by cluster analysis and primary component analysis results. Ingestion of dust particles appeared to be the main route of exposure to re-suspended dust. Hazard Indexes of As were both highest for children and adult which could be a potential threat to human health for non-cancer effect and it also exhibited the highest values for cancer effect as 1.01×10^{-6}, 7.04×10^{-7} and 7.21×10^{-7} for $PM_{2.5}$, PM_{10} and PM_{100}, respectively.

12/01588 Reducing energy penalties in carbon capture with organic Rankine cycles

Romeo, L. M. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2928–2935.

Carbon capture and storage are considered one of the most promising technologies to reduce emissions in a midterm. Its main drawback is the energy penalty caused by the CO_2 separation and compression processes. It increases the CO_2 avoided cost and it is an important driving force to propose new and improved capture methods with lower energy requirements. In the case of oxyfuel systems, power plant efficiency penalty is 10–13 percentage points. It is mainly caused by the air separation unit and CO_2 compression. The possibilities for the integration of these two necessary processes are limited due to the low temperature of their waste energy. One possibility to take advantage of this low-temperature heat is by using organic Rankine cycles, which generate power by means of an organic compound as working fluid. This paper proposes the integration of an ORC with the low-temperature processes associated with oxyfuel combustion in order to reduce its energetic penalty. Results show that a reduction in power requirements around 25% could be achieved. It decreases the efficiency penalty from 11 to 8.2 percentage points and contributes to make more attractive this technology. A comparison between different organic compounds is also conducted to select the suitable substances which minimize penalties in the integration process.

12/01589 Relationship of indoor and outdoor air pollutants in a naturally ventilated historical building envelope

López-Aparicio, S. *et al. Building and Environment*, 2011, 46, (7), 1460–1468.

Concentrations of NO_2, O_3, SO_2, acetic and formic acids, HNO_3 and NH_3 were measured inside and outside a historical building, the Baroque Library Hall (BLH) in the National Library in Prague (Czech Republic). The naturally ventilated system of the building, the restriction of personnel access, reduced groups of visitors and absence of activities which could influence indoor pollutant concentrations are characteristics that make the Baroque Library Hall a suitable location to study the influence of outdoor environment on the indoor air quality. The relationship between indoor and outdoor (I/O) concentration was investigated to assess the infiltration of outdoor generated pollutants. Outdoor and indoor pollution sources were determined and, infiltration of ammonium nitrate and a shift of the equilibrium to the gas phase were the reason for the high concentration of ammonia measured inside the BLH. A significant seasonal variation was observed and interpreted as a consequence of different infiltration regime associated with indoor–outdoor temperature differences, which in addition drives dilution processes of indoor generated pollutants. Based on the indoor air quality assessment performed in the BLH with regard to human and material exposure, there is reason for concern about material preservation and in particular paper at the BLH.

12/01590 Scrutinizing inter-relations between performance influencing factors and the performance of human operators pertaining to the emergency tasks of nuclear power plant – an explanatory study

Park, J. *et al. Annals of Nuclear Energy*, 2011, 38, (11), 2521–2532.

There is no doubt about the fact that reliable human performance is the key to the safe operation of human involved safety–critical systems. For this reason, it is necessary to understand (1) which factors (e.g. performance influencing factors; PIFs) affect the performance of human operators and (2) inter-relations between the significant PIFs and human performance variations. Unfortunately, a systematic framework by which these inter-relations can be properly identified seems to be scant. Therefore, in this study, the features of task complexity measure called TACOM are revisited. As a result, it is strongly expected that the TACOM measure can be used as a common tool for representing the characteristics of task related PIFs. Therefore, although additional studies are indispensable to establish more reliable technical basis, it is believed that the TACOM measure plays an important role in scrutinizing the effect of significant PIFs on the performance of human operators.

12/01591 Socio-technological impact analysis using an energy IO approach to GHG emissions issues in South Korea

Chung, W.-S. *et al. Applied Energy*, 2011, 88, (11), 3747–3758.

Through energy input–output (E-IO) analyses from 1985 to 2005, the changes in three factors affecting greenhouse gas (GHG) emissions in South Korea were analysed. Based on the E-IO results, the changes in the direct and total (embodied) GHG emissions from the pertinent sectors were decomposed into three factors (the energy consumption effect, the social effect, and the technological effect), using the Sato-Vartia index for the three periods of 1985–1995, 1995–2000, and 2000–2005. The decomposition analysis demonstrated that a total emission matrix including both direct and indirect GHG emissions showed an evolution pattern that was very similar to the changes in direct GHG emissions; however, ripple effects were observed in the case of emissions from sector 59 (synthetic resins, synthetic rubber-p). The results showed that national energy policies such as those pertaining to the diversification of energy sources, shifts in the energy consumption structure (social effect), and the transformation to a low-carbon energy economy (technology effect) were effective. Finally, several limitations of the Divisia decomposition analysis were pointed out.

12/01592 Sustainability assessment and rating of buildings: developing the methodology SBTool^{PT}–H

Mateus, R. and Bragança, L. *Building and Environment*, 2011, 46, (10), 1962–1971.

Although sustainable building is a multidimensional concept, attention to the issue often focuses solely on environmental indicators, ignoring the substantial importance of social, economic and cultural indicators. Building sustainability involves various relations between built, natural and social systems and therefore comprises a complex of different priorities that require consideration at each stage of a building's life-cycle. To cope with this complexity and to support sustainability systematic, holistic and practical approaches to building design need to be developed. The main objective of a systematic methodology is to support the development of a building design that achieves the most appropriate balance between the different sustainability dimensions, and is, at the same time, practical, transparent and flexible enough to be easily adapted to different types of buildings and technology. It is the aim of this paper to present an innovative approach for developing building sustainability assessment and rating, and to contribute to the evolution of generic methodology and international understanding by introducing an approach which takes the different dimensions of sustainability into account. The scope of the methodology presented in this paper (SBTool^{PT}–H) is to assess the sustainability of existing, new and renovated residential buildings in urban areas, specifically in the Portuguese context.

12/01593 The crepuscular planet. A model for the exhausted atmosphere and hydrosphere

Valero, A. *et al. Energy*, 2011, 36, (6), 3745–3753.

The crepuscular Earth presented here is a guess reference model of the planet in which all mineral resources have been extracted and dispersed and fossil fuels have been burnt. It serves as a realistic limit of resources to assess the Earth's non-renewable exergy capital. Under such conditions a state of the atmosphere and hydrosphere is estimated using updated fossil fuels stocks (1925 GtC for proven reserves, rising to about 16,224 GtC when including estimated additional reserves) and emissions projections in a simple model of the carbon cycle. The authors consider the BAU-I scenario as the most likely to occur, corresponding to an atmospheric injection of about 2000 GtC. Accordingly, a crepuscular atmosphere is proposed having a carbon dioxide content of 683 ppm, a mean surface temperature of 17 °C (peak carbon dioxide induced warming of 3.7 °C above pre-industrial temperatures), a pressure of 1.021 bar, and a composition in volume basis of 78.8% N_2, 20.92% O_2, 0.93% Ar, and 0.0015% of trace gases. Considering that oceans account for 97.5% of the whole hydrosphere, the crepuscular hydrosphere is assumed to have the current chemical composition of the oceans at an average temperature of 17 °C.

12/01594 The role of measurement accuracy on the thermal environment assessment by means of PMV index

d'Ambrosio Alfano, F. R. *et al. Building and Environment*, 2011, 46, (7), 1361–1369.

The ISO 7730 standard classifies thermal environments in three categories as a function of the PMV range value, gradually decreasing according to the need of a lower dissatisfied percentage. It is noteworthy that the PMV value is greatly affected by the changes of its independent variables (air temperature, mean radiant temperature, air velocity, relative humidity, metabolic rate and clothing insulation); therefore the accuracy requirements of sensors for the measurement of environmental quantities as well the assessment of other parameters related to the activity and clothing appear a crucial matter. This work deals with a sensitivity analysis of PMV index to the accuracy of its six independent variables. Obtained results clearly show that the widths of PMV ranges fixed for each class in 7730 are near to the PMV uncertainty related to measuring devices accuracy, making often the environment classification a random operation.

12/01595 The significance of vehicle emissions standards for levels of exhaust pollution from light vehicles in an urban area

Rhys-Tyler, G. A. *et al. Atmospheric Environment*, 2011, 45, (19), 3286–3293.

This paper addresses the research question 'Are more stringent exhaust emissions standards, as applied to light vehicle type approval, resulting in reduced vehicle pollution in an urban area?' The exhaust emissions of a sample of over 50,000 road vehicles operating in London were measured using roadside remote sensing absorption spectroscopy techniques (infrared and ultraviolet), combined with automatic number plate recognition for vehicle identification. Levels of carbon monoxide (CO), hydrocarbons (HC), nitric oxide (NO), and smoke (particulate) exhaust emissions are reported by vehicle class, fuel type, and Euro emissions standard. Emissions from petrol cars of each pollutant were all observed to display a statistically significant reduction with the introduction of each successive Euro emissions standard from Euro 1 onwards. However, Euro 2 diesel cars were observed to emit statistically higher rates of NO than either Euro 1 or Euro 3 standard diesel cars. The study also confirms the continuing 'dieselization' of the UK passenger car fleet. Mean NO emissions from Euro 4 diesel cars were found to be six times higher than Euro 4 petrol cars, highlighting the need to develop a sound understanding of the current and future 'in-use' emissions characteristics of diesel vehicles, and their influence on local air quality. Smoke emissions from TXII London taxis (black cabs) were found to be statistically higher than either earlier TX1 or later TX4 model variants, with possible implications for local air quality policy interventions such as maximum age limits for taxis.

12/01596 Trade-linked Canada–United States household environmental impact analysis of energy use and greenhouse gas emissions

Ferguson, T. M. *et al. Energy Policy*, 2011, 39, (12), 8011–8021.

This paper compares energy use and greenhouse gas (GHG) emissions associated with total household expenditures and activities in Canada and the USA in 1997, the first detailed estimate of environmental burdens for Canadian households. The direct burdens are estimated from published government data and indirect burdens using an industry-by-commodity, bi-national economic input–output life cycle assessment model developed in this study. Comparing 30 expenditure and two activity categories, per capita US household expenditures were 70% higher, while per capita household energy use and GHG emissions were only 10% and 44% higher, respectively. Energy use/dollar of expenditure was higher in most Canadian categories, while the average ratio of GHG emissions/energy use was higher in the USA (65 vs 50 kg Eq. CO_2/GJ) due largely to a higher proportion of electricity from non-renewable sources. Indirect environmental burdens represented 63–69% of total burdens and 62–70% of total burdens were associated with household operation and transportation. Key drivers of differences between energy profiles were: higher per capita electricity use by Canadian households, and higher US household private health care expenditures and motor fuel use. Energy-intensive production for export represented a higher proportion of Canadian production, resulting in less agreement between consumption and production-based analyses for Canada than USA.

CO_2, NO_x, SO_2 and particulate emissions

12/01597 A novel and dynamic demand-controlled ventilation strategy for CO_2 control and energy saving in buildings

Lu, T. *et al. Energy and Buildings*, 2011, 43, (9), 2499–2508.

Although conventional CO_2-based demand-controlled ventilation strategies, such as proportional and exponential controls, can ensure buildings/spaces meeting the minimum requirements of outdoor air by industry standards, they are operated under the assumption of equilibrium condition which can hardly be reached in practice and therefore there is still much space to improve on conventional strategies in terms of energy saving. In this paper, a novel and dynamic control strategy was developed for hourly scheduled buildings. The strategy utilized schedules by setting a base ventilation rate for unoccupied periods and calculating ventilation rate dynamically at each occupied period by solving the CO_2 mass balance equation to keep indoor CO_2 near the set point during the occupied period. Experimental simulations were made over a sports training centre using both simulated and experimental CO_2 generation rates. Results show that the new strategy can save +34% of energy related to ventilation air compared to proportional control. The new strategy was also extended to common buildings which are occupied for almost all opening hours. In the case of common buildings, the new strategy can save about +26% of energy related to ventilation air compared to proportional control. The new strategy is simple, dynamic, flexible and efficient.

12/01598 Assessing the potential of hybrid energy technology to reduce exhaust emissions from global shipping

Dedes, E. K. *et al. Energy Policy*, 2012, 40, 204–218.

The combination of a prime mover and an energy storage device for reduction of fuel consumption has successfully been used in automotive industry. The shipping industry has used this for conventional submarines. The potential of a load levelling strategy through use of a hybrid battery–diesel–electric propulsion system is investigated. The goal is to reduce exhaust gas emissions by reducing fuel oil consumption through consideration of a re-engineered ship propulsion system. This work is based on operational data for a shipping fleet containing all types of bulk carriers. The engine loading and the energy requirements are calculated, and sizing of suitable propulsion and the battery storage system are proposed. The changes in overall emissions are estimated and the potential for fuel savings identified. The efficiency of the system depends on the storage medium type, the availability of energy and the displacement characteristics of the examined vessels. These results for the global fleet indicate that savings depending on storage system, vessel condition and vessel type could be up to 0.32 million tonnes in NO_x, 0.07 million tonnes in SO_x and 4.1 million tonnes in CO_2. These represent a maximum 14% of reduction in dry bulk sector and 1.8% of world's fleet emissions.

12/01599 Biofuels carbon footprints: whole-systems optimisation for GHG emissions reduction

Zamboni, A. *et al. Bioresource Technology*, 2011, 102, (16), 7457–7465.

A modelling approach for strategic design of ethanol production systems combining lifecycle analysis (LCA) and supply chain optimization (SCO) can significantly contribute to assess their economic and environmental sustainability and to guide decision makers towards a more conscious implementation of ad hoc farming and processing practices. Most models applications so far have been descriptive in nature; the model proposed in this work is 'normative' in that it aims to guide actions towards optimal outcomes (e.g. optimizing the nitrogen balance through the whole supply chain). The modelling framework was conceived to steer strategic policies through a geographically specific design process considering economic and environmental criteria. Results shows how a crop management strategy devised from a whole systems perspective can significantly contribute to mitigate global warming even in first generation technologies.

12/01600 Critique of the regulatory limitations of exhaust CO_2 emissions from passenger cars in European Union

Bampatsou, C. and Zervas, E. *Energy Policy*, 2011, 39, (12), 7794–7802.

Transport is the second emitter of CO_2 in the European Union (EU), after the energy production sector, with constantly increased trend. European Union proposed the regulation 443/2009 to control the carbon dioxide emissions from new passenger cars. According to that regulation, the average, for each car manufacturer, carbon dioxide emissions of the new passenger cars registered in 2020 in EU should not exceed the value of 95 g CO_2/km on the New European Driving Cycle. In the present work the regulation 443/2009 is analysed and a critique is addressed to four points. The first point concerns the average upper limit of carbon dioxide emissions of each car manufacturer. The second point concerns the possible derogation for the low volume manufacturers and the third to the penalties for the extra carbon dioxide emissions. The fourth point concerns the value of the proposed average upper limit of carbon dioxide emissions and the possibility to be changed in the future. A change to the above points is proposed. The maximum decrease of carbon dioxide emissions and the principle of equality of citizens are the two principles of the propositions for the carbon dioxide regulations.

12/01601 Deep greenhouse gas reduction scenarios for California – strategic implications from the CA-TIMES energy-economic systems model

McCollum, D. *et al. Energy Strategy Reviews*, 2012, 1, (1), 19–32.

California has taken a leading role in regulating greenhouse gas (GHG) emissions, requiring that its economy-wide emissions be brought back down to the 1990 level by 2020. The state also has a long-term, aspirational goal of an 80% reduction below the 1990 level by 2050. While the steps needed to achieve the near-term target have already been clearly defined by California policy makers, the suite of transformational technologies and policies required to decarbonize the energy system over the long term have not yet been explored. This paper describes an effort to fill this important gap, introducing CA-TIMES, a bottom-up, technologically-rich, integrated energy–engineering–environmental–economic systems model that has been developed to guide the long-term policy planning process. CA-TIMES is useful for exploring low-carbon scenarios, and the analyses described here focus on the potential evolution of the transportation, fuel supply, and electric generation sectors over the next several decades in response to various energy and climate policies. It is found that meeting California's 80% emission reduction goal can be achieved through a combination of mitigation strategies, including managing the growth in energy service demand, increasing investments in efficiency and low-carbon energy supply technologies, and promoting demand technologies that facilitate end-use device electrification and a decrease in the direct use of hydrocarbon fuels through efficiency improvement and fuel switching. In such deep emission reduction scenarios, it is estimated that energy system costs (accounting for investments on the energy supply side and in transportation demand technologies, as well as fuel and O&M costs) could be around 8–17% higher than in a reference case. Meanwhile, average abatement costs could range from \$107 to \$225/tCO_2. These estimates are very much dependent on a range of socio-political and technological uncertainties, for instance, the availability and cost of biomass, nuclear power, carbon capture and storage, and electric and hydrogen vehicles.

12/01602 Degradation of NO using photocatalytic coatings applied to different substrates

Martinez, T. *et al. Building and Environment*, 2011, 46, (9), 1808–1816.
This article deals with the degradation of NO present in the air by means of a photocatalytic oxidation process based on TiO_2 nanoparticles incorporated in a polymer-matrix-based coating. The experimental set-up consisted of a flow type reactor adapted from the ISO 22197–1 standard. NO_2 in the gas phase, and nitrate ions adsorbed on the photocatalytic surface were detected as finals products. Various parameters influencing the NO degradation efficiency were studied: the coating composition, the substrate nature, the initial concentration of NO, the polluted air flow rate and the humidity. Compared to glass, the use of mortar as the substrate enhanced the photocatalytic performance of coatings by reducing the generation of gaseous NO_2 as a by-product.

12/01603 Greenhouse gas emission mitigation potential of rice husks for An Giang province, Vietnam

Thao, P. T. M. *et al. Biomass and Bioenergy*, 2011, 35, (8), 3656–3666.
To evaluate the greenhouse gas (GHG) emission mitigation potential of rice husk utilization, a life cycle inventory analysis was conducted for 18 scenarios. The allocation of fuels, other than rice husks, was decided based on the current demand for and supply of rice husks. To prevent the bulky nature of rice husks, briquette production is also discussed. In the power generation scenarios, the differences between two capacities (5 and 30 MW) were analysed. The results of analysis reveal that CH_4 and N_2O emissions from open burning contribute largely to the current GHG emissions. Therefore, ceasing open burning alone has a large GHG mitigation potential. The use of briquettes, even though GHG is emitted during the production stage, can still contribute to GHG emission mitigation as the production is more efficient than rice husk burning or dumping. In the power generation scenarios, most GHG emissions were derived from the combustion process. Therefore, gasification which has a little combustion process is the most efficient GHG mitigator. Both the replacement of grid electricity by generated electricity, and the replacement of diesel oil by pyrolysed oil show larger GHG mitigation potentials than what could be derived from open burning cessation alone.

12/01604 Greenhouse gas emissions, energy consumption and economic growth: a panel cointegration analysis from Canadian industrial sector perspective

Hamit-Haggar, M. *Energy Economics*, 2012, 34, (1), 358–364.
This paper investigates the long-run and the causal relationship between greenhouse gas (GHG) emissions, energy consumption and economic growth for Canadian industrial sectors over the period 1990–2007. The empirical findings suggest that in the long-run equilibrium, energy consumption has a positive and statistically significant impact on GHG emissions whereas a non-linear relationship is found between GHG emissions and economic growth, consistent with the environmental Kuznets curve. The short-run dynamics conveys that there is a unidirectional Granger causality running from energy consumption to GHG emissions; from economic growth to GHG and a weak unidirectional causality running from GHG emissions to energy consumption; from economic growth to energy consumption. In the long-run however, there seems to be a weak one way causality flowing from energy consumption and economic growth to GHG emissions.

12/01605 Higher than expected NO_x emission from trucks may affect attainability of NO_2 limit values in the Netherlands

Velders, G. J. M. *et al. Atmospheric Environment*, 2011, 45, (18), 3025–3033.
In past years, the European limit value for average annual NO_2 concentration has been exceeded in city streets and along motorways in the Netherlands. By 2015 the limit value must be adhered to in the Netherlands. Although the total road length for which exceedance is likely is expected to decrease over the coming years, exceedances may still occur by 2015. Future NO_2 concentrations not only depend on economic growth, current and proposed policies, and on inevitable meteorological fluctuations, they also depend on the effectiveness of technical measures to reduce emissions. New emission measurements for heavy-duty vehicles in the Euro-V (and Euro-III) emission standard categories, carried out under typical Dutch driving conditions, have revealed that real-world NO_x emissions from these trucks are significantly higher than was previously estimated based on the reduction steps in the Euro emission standards. Emission levels were higher, by about a factor of three, along city streets, and 10–40% higher along motorways. These higher emission levels resulted in higher estimated national NO_x emissions, increasing from 250 kt to 264 kt, compared with the national emission ceiling of 260 kt, to be adhered to by 2010. The higher emissions more than double the total road length with possible exceedance (chance $>33\%$) of the NO_2 limit value; from about 100 km to about 250 km along cities streets and motorways, by 2015. These higher emissions from trucks, therefore, affect the chances of the limit values being adhered to, in time, everywhere in the Netherlands.

12/01606 Lean-burn NO_x emission control via simulated stack of solid oxide fuel cells with Cu-added (LaSr)MnO_3 cathodes

Huang, T.-J. *et al. Chemical Engineering Journal*, 2011, 172, (2–3), 665–670.
A stack of solid oxide fuel cells (SOFCs) can be used as an automotive catalytic converter for lean-burn NO_x emission control. With a simulated SOFC stack, it is demonstrated that this converter can reduce NO_x in the lean-burn engine exhaust to zero no matter how large the inlet NO_x concentration is. An SOFC unit operating at 600 °C was constructed with Ni–YSZ as the anode, YSZ as the electrolyte, and Cu-added $La_{0.8}Sr_{0.2}MnO_3$–$Ce_{0.9}Gd_{0.1}O_{1.95}$ as the cathode. The NO_x conversion increases not only with decreasing NO concentration in the low NO concentration range but also with increasing NO concentration in the high NO concentration range. In addition, the NO_x conversion increases with increasing O_2 concentration and can increase with adding SO_2. Simultaneous control of CO emission via oxidation can be performed in this converter.

12/01607 Long-term trend in NO_2 and NO_x levels and their emission ratio in relation to road traffic activities in east Asia

Shon, Z.-H. *et al. Atmospheric Environment*, 2011, 45, (18), 3120–3131.
Long-term trend in emission ratio of NO_2 to NO_x was analysed in relation to traffic activities using ambient monitoring data (such as NO, NO_2, NO_x, and O_3) collected from seven urban roadside (U-RS) and seven urban background (U-BG) locations in Seoul, Korea over a 14-year period (1996–2009). In general, the temporal trend of NO_2 concentrations is less distinctive than that of NO_x, whether being downward or upward. However, if their differences are checked statistically, only a few cases were significant. The mean emission ratio of NO_2 to NO_x values varied slightly across the seven U-RS sites during the study period, ranging from 0.11 to 0.19. In general, there was no significant annual trend in the relative fraction of NO_2 in NO_x emission (f(NO_2)) at U-RS, with an exceptional downward trend at one site (slope of $-0.008\,y^{-1}$). On the other hand, diurnal variations of f(NO_2) were likely affected by driving conditions and fuel type of vehicles. The overall results of this study suggest that NO_x emission control strategies such as diesel particulate filter (DPF) or diesel oxidation catalyst (DOC) should have direct influences on f(NO_2) values at U-RS sites.

12/01608 Quantifying the contributions of individual NO_x sources to the trend in ozone radiative forcing

Dahlmann, K. *et al. Atmospheric Environment*, 2011, 45, (17), 2860–2868.
Source attribution of ozone radiative forcing (RF) is a prerequisite for developing adequate emission mitigation strategies with regards to climate impact. Decadal means of ozone fields from transient climate-chemistry simulations (1960–2019) are analysed and the temporal development of ozone RF resulting from individual NO_x sources, e.g. road traffic, industry and air traffic, is investigated. An ozone production efficiency was calculated, which is mainly dependent on the altitude of NO_x emission and on the amount of background NO_x with values varying over one order of magnitude. Air traffic and lightning are identified as NO_x sources with a two and five times higher ozone production efficiency, respectively, than ground based sources. Second, radiative efficiency of source attributed ozone (i.e. total induced radiative flux change per column ozone) shows clear dependence on latitudinal structure of the ozone anomaly and, to a lesser extent, to its altitude. Lightning induced ozone shows the highest radiative efficiency because lightning primarily enhances ozone in low latitudes in the mid-troposphere (higher altitudes). Superimposed on these effects, a saturation effect causes a decreasing radiative efficiency with increasing background ozone concentrations. Changes in RF attributed to NO_x induced ozone from 1960 to 2019 are controlled by three factors: changes in emissions, changes in ozone production efficiency and changes in the radiative efficiency. Leading effect is emission increase, but changes in ozone production efficiency increase ozone RF by a factor of three for air traffic, or reduce ozone RF by around 30% for ships. Additionally, changes in the radiative efficiency due to saturation effects change ozone RF by 2–5%.

12/01609 Reactive nitrogen compounds (RNCs) in exhaust of advanced PM–NO_x abatement technologies for future diesel applications

Heeb, N. V. *et al. Atmospheric Environment*, 2011, 45, (18), 3203–3209.
Long-term exposure to increased levels of reactive nitrogen compounds (RNCs) and particulate matter (PM) affect human health. Many cities are currently not able to fulfil European air quality standards for these critical pollutants. Meanwhile, promising new abatement technologies such as diesel particle filters (DPFs) and selective catalytic reduction

(SCR) catalysts are developed to reduce PM and RNC emissions. Herein, effects of a urea-based SCR system on RNC emissions are discussed and the highly reactive intermediates isocyanic acid (HNCO) and ammonia (NH_3) are quantified, both potential secondary pollutants of the urea-based SCR chemistry. A diesel engine (3.0 L, 100 kW), operated in the ISO 8178/4 C1, cycle was used as test platform. A V_2O_5-based SCR catalyst was either applied as such or down-stream of a high oxidation potential-DPF (hox-DPF). With active SCR, nitric oxide (NO) and nitrogen dioxide (NO_2) conversion efficiencies of 0.86–0.94 and 0.86–0.99 were obtained. On the other hand, mean HNCO and NH_3 emissions increased to 240–280 and 1800–1900 mg h $^{-1}$. On a molar basis, HNCO accounted for 0.8–1.4% and NH_3 for 14–25% of the emitted RNCs. On roads, SCR systems will partly be inactive when exhaust temperatures drop below 220 °C. The system was active only during 75% of the test cycle, and urea dosing was stopped and restarted several times. Consequently, NO conversion stopped but interestingly, NO_2 was still converted. Such light-off and shutdown events are frequent in urban driving, compromising the overall deNO_x efficiency. Another important effect of the SCR technology is illustrated by the NH_3/NO_2 ratio, which was >1 with active SCR, indicating that exhaust is basic rather than acidic after the SCR catalyst. Under these conditions, isocyanic acid is stable. The widespread use of various converter technologies already affected RNC release. Diesel oxidation catalysts (DOCs) and hox-DPFs increased NO_2 emissions, three-way catalysts (TWCs) those of NH_3. The investigated SCR technology substantially lowered NO and NO_2 emissions, while NH_3 levels were comparable to those of TWC vehicles (300–1500 mg h $^{-1}$). If applied in the future, the combined DPF/SCR technology will change ambient RNC levels, PM compositions and atmospheric redox- and acid/base-chemistry in traffic-affected areas.

12/01610 Reactivity of NH_3 over (Fe)/H-ZSM-5 zeolite: studies of temperature-programmed and steady-state reactions

Chen, X. *et al. Catalysis Today*, 2011, 175, (1), 2–11.

The NH_3 reactivity was investigated over H-ZSM-5 and iron oxide deposited H-ZSM-5 by temperature-programmed surface interaction (TPSI) of adsorbed NH_3 (NH_3(ad)) with NO, O_2, and '$NO + O_2$', and by steady-state dynamic reactions consisting of '$NH_3 + NO$', '$NH_3 + O_2$', and '$NH_3 + NO + O_2$' systems. It was found that O_2 primarily interacts with NH_3(ad) on Brønsted acid sites. NO mainly interacts with NH_3(ad) on Lewis acid sites, whereas its interaction with NH_3(ad) on Brønsted acid sites results in N_2O formation. TPSI provides direct evidence of the 'fast' reaction of NO/NO_2 with NH_3(ad) on Brønsted acid sites in '$NO + O_2$' environment, where O_2 concentration plays a critical role. Iron oxide enhances all interactions, particularly those with NH_3(ad) on Brønsted acid sites, as witnessed by both TPSI and steady-state reactions. But, iron oxide does not change the activation energy barrier for NH_3 conversion, indicating that both acid sites and iron oxide are essential for NH_3 SCR of NO_x. As a result, a dual mechanism over Lewis and Brønsted acid sites was proposed.

12/01611 Sectoral CO_2, CH_4, N_2O and SO_2 emissions from fossil fuel consumption in Nagpur City of Central India

Majumdar, D. and Gajghate, D. G. *Atmospheric Environment*, 2011, 45, (25), 4170–4179.

Emission inventory of CO_2, CH_4, N_2O and SO_2 has been prepared for Nagpur city in Central India for the year 2004. Data on fossil fuel (coal, light diesel oil, high speed diesel, petrol/gasoline, low sulfur heavy stock, furnace oil and kerosene) consumption in thermal power, industrial, transport and domestic sectors were collected. Thermal power sector had the maximum coal consumption followed by the industrial and domestic sectors, whereas kerosene, liquefied petroleum gas (LPG), diesel and gasoline were used only in any single sector. Total annual CO_2, CH_4, N_2O and SO_2 emissions from these fuels in Nagpur city for the year 2004 was found to be 14792418 MT (14.8 Tg), 4649 (4.6 Tg), 1529 (1.5 Tg) and 69093 (6.9 Tg), respectively, in which thermal power and domestic sector had the maximum share. Coal was found to be the major contributor to greenhouse gas and SO_2 emissions in all the sectors barring transport and domestic sectors. Carbon dioxide was the predominant GHG emitted by the selected sectors in terms of absolute emissions and also global warming contribution, although the share in the latter was lesser in magnitude due to higher global warming potential of CH_4 and N_2O than CO_2. Thermal power sector had a share of 51% in total CO_2 emissions from all the sectors, followed by domestic, industrial and transport sectors having 27, 12 and 10% contributions, respectively. Share of thermal power sector in total SO_2 emissions was 61%, followed by 24% from industrial, 10% from domestic and 5% from transport sector.

12/01612 Semiempirical in-cylinder pressure based model for NO_x prediction oriented to control applications

Guardiola, G. *et al. Applied Thermal Engineering*, 2011, 31, (16), 3275–3286.

This work describes the development of a fast NO_x predictive model oriented to engine control in diesel engines. The in-cylinder pressure is the only instantaneous input signal required, along with several mean variables that are available in the ECU during normal engine operation. The proposed model is based on the instantaneous evolution of the heat release rate and the adiabatic flame temperature (both obtained among other parameters from the in-cylinder pressure evolution). Corrections for considering the NO_x reduction due to the re-burning mechanism are also included. Finally, the model is used for providing a model-based correction of tabulated values for the NO_x emission at the reference conditions. The model exhibits a good behaviour when varying exhaust gas recirculation rate, boost pressure and intake temperature, while changes in the engine speed and injection settings are considered in the tabulated values. Concerning the calculation time, the model is optimized by proposing simplified sub-models to calculate the heat release and the adiabatic flame temperature. The final result is suitable for real time applications since it takes less than a cycle to complete the NO_x prediction.

12/01613 Support effect on the NO_x storage and sulfur-resisting performance of the NO_x trap catalysts $Pt/Li/TiO_2$–MO_x (M = Al, Zr, Si, Sn)

Meng, M. *et al. Catalysis Today*, 2011, 175, (1), 72–77.

A series of Li-based lean-burn NO_x trap (LNT) catalysts $Pt/Li/TiO_2$–MO_x (M = Al, Zr, Si, Sn) were prepared by sequential impregnation with the supports TiO_2–MO_x synthesized by co-precipitation. The support effect on the NO_x storage and sulfur-resisting performance of $Pt/Li/TiO_2$–MO_x catalysts was investigated carefully. The NO_x storage capacity of fresh $Pt/Li/TiO_2$ is greatly improved by doping with Al_2O_3 or ZrO_2 due to the remarkably increased specific surface area and the oxidation ability of the catalysts. HR-TEM and H_2-chemisorption results reveal that the oxidation ability of $Pt/Li/TiO_2$–MO_x is mainly determined by Pt crystallite size. Larger Pt crystallites correspond to stronger oxidation ability. The regeneration of sulfated $Pt/Li/TiO_2$–MO_x strongly depends on the total acidity of the supports, including Brønsted and Lewis acid; the supports with larger acidity possess higher ability of sulfur-resistance and regeneration. The results of *in situ* DRIFTS show that over $Pt/Li/TiO_2$–MO_x (M = Al, Zr, Si, Sn) NO_x is mainly stored as ionic nitrate species at 350 °C. Taking the NSC and regeneration ability into account, the catalyst $Pt/Li/TiO_2$–Al_2O_3 is the most promising one for practical application.

12/01614 Thermo-hydraulic characterization of an automotive intercooler for a low pressure EGR application

Cuevas, C. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2474–2484.

In this work an experimental study is carried out to determine the thermo-hydraulic performance of an intercooler (IC) with flat tubes provided with triangular plain internal fins and louvered external fins when it is used on a car equipped with a low pressure EGR. The main unknowns to be answered are the thermo-hydraulic characteristics of the IC working under humid conditions induced by EGR, the conditions under which the water content in the mixture of air and exhaust gases begins to condense and the conditions under which the condensed water will be retained inside the IC. The exhaust gases are here replaced by a mixture of dry air and water vapour which are mixed upstream of the IC. The IC is submitted at the following testing conditions: on the ambient air side, the air temperature is fixed at around 20 °C and the air velocity is settled at 1, 2 and 4 m s $^{-1}$; on the exhaust gases side, the supply temperature was varied between 90 and 150 °C, with dry gas flow rates of 20, 50 and 100 g s $^{-1}$, and water contents varying between almost 0 and 0.09 $kg_w\,kg_g{}^{-1}$. At these conditions the IC transfers between 1 and 13 kW with overall heat transfer conductance varying between 0.05 and 0.38 kW K $^{-1}$ and effectivenesses between 0.3 and 0.97. A water accumulation inside the IC was detected for the tests carried out at low dry gas flow rate of 20 g s $^{-1}$ and for all the water content explored here (higher than 0.02 $kg_w\,kg_g{}^{-1}$).

12/01615 Zero energy balance and zero on-site CO_2 emission housing development in the Mediterranean climate

Ferrante, A. and Cascella, M. T. *Energy and Buildings*, 2011, 43, (8), 2002–2010.

Zero-energy balance (ZEB) is an essential and paramount topic in building design. The paper addresses this important research area with special regard to the Mediterranean climate. To deal with ZEB in architecture, a final design proposal for a new housing development in the peri-urban context of Tricase – a town located in the south of Italy – is presented and used for energy investigation. With reference to this pilot case study, the paper highlights that high performing and zero energy balance buildings cannot be reached by technology alone, but by the search for an integrated design combining passive tools (high thermal mass brick wall structures – as an evolution of the traditional stone construction of the region, high reflective materials, solar shading devices, ventilation strategies, etc.) with solar and wind energy micro-generation. Results show that zero energy balance and zero local CO_2 emission houses in the Mediterranean climate present high levels of feasibility, which can be simply achieved by energy-efficient solutions using local materials and traditional construction processes, thus resulting into high quality performing buildings within recognizable urban environments.

Hydrocarbon emissions

12/01616 Air quality assessment in a highly industrialized area of Mexico: concentrations and sources of volatile organic compounds

Vega, E. *et al. Fuel*, 2011, 90, (12), 3509–3520.

Parallel to the economic benefits brought by the oil industry in Mexico, there have been some negative environmental effects due to emission of pollutants to the atmosphere. Salamanca, a city located inside one of the most important industrial corridors of the country, has been frequently affected by elevated concentrations of sulfur dioxide and particle matter. However, little is known about volatile organic compounds (VOCs), which in this study are analysed along with criteria pollutants and meteorological parameters during February to March 2003 at urban, suburban and rural sites. Although sulfur dioxide average levels were $\sim$0.017 ppm, a high concentration event ($\sim$0.600 ppm), attributable to emissions from the oil refinery and the thermoelectric power plant, was observed at the urban site at night time. The VOCs concentration varied from 170 ± 50 ppbC (rural) to 699 ± 212 (urban) and were constituted by 40% alkanes, 13% aromatics, 11% olefins and 11% of halogenated. The most abundant species were propane (167 ± 40 ppbC), *n*-butane (91 ± 23 ppbC), toluene (51 ± 10 ppbC) and *i*-pentane (44 ± 7 ppbC), that are related to combustion processes. Freon-114, methyl bromide and 1,2-dichloroethane which are likely emitted by application of pesticides, soil fumigation and fabrication of chemicals, showed high concentrations (48 ± 10, 50 ± 10 and 32 ± 6 ppbC respectively) in the rural sites, highlighting the importance of control measurements implementation for these species, as they represent a potential hazard for public health. Moreover, these halocarbons showed similar ratios regardless the monitoring site, suggesting same source. Modelling results indicated that meteorological conditions generally transport air masses to the northeast rural areas where the highest concentrations of ozone were calculated.

12/01617 Background concentrations and source apportionment of polycyclic aromatic hydrocarbons in south-eastern Finland

Vestenius, M. *et al. Atmospheric Environment*, 2011, 45, (20), 3391–3399.

Polycyclic aromatic hydrocarbons (PAH compounds) were measured in the PM_{10} fraction (from ambient air) at Virolahti, Finland. The sampling site is located in a rural area in the south-eastern corner of Finland, near the Russian border. Altogether, 51 daily and 85 weekly filter samples were collected in 2007–2008. The yearly average concentration of benzo(a)pyrene at Virolahti in 2007 was 0.21 ng m^{-3}, which is well below the annual target value of 1 ng m^{-3} set by the European Union. The positive matrix factorization (PMF) method was applied in source apportionment for daily PAH data combined with other pollutant data. A three-factor solution of the PMF analysis with 28 components was chosen. These three factors were identified as long-range transported secondary particles (F1), combustion (F2) and a sea-salt factor (F3). The conditional probability function (CPF) was used to combine wind direction sectors with the PMF factors. In cases F1 and F2, pollutants mainly originated from the south-east, whereas pollutants in F3 came from the south-western sector. PAHs entered into the combustion factor 2 together with SO_2, NO_x, black carbon and potassium. This suggests that the PAHs at Virolahti originated from traffic and industrial pollution, as well as biomass burning. Elevated concentrations occurred throughout the winter period and most frequently originated from the south-eastern sector between 90° and 135°. This sector includes, among other transboundary areas, the metropolis of St Petersburg at a distance of 160 km.

12/01618 Determination of polycyclic aromatic hydrocarbons in domestic pellet stove emissions

Riva, G. *et al. Biomass and Bioenergy*, 2011, 35, (10), 4261–4267.

Biomass is one of the most important renewable energy sources that could help to achieve the 2020 targets set by European Directive 2009/28. This is particularly true in Italy where the government plans to replace a final energy use corresponding to 200–250 PJ through the use of small wood stoves/boilers for domestic heating (<35 kW). This corresponds to about 25% of the national target for 2020. However, this solution is under discussion because of the environmental problems that poses in terms of emissions of PM and PAHs especially in lowland areas. The study, starting from these assumptions, was focused to characterize, with laboratory tests, the composition of PAHs emitted by a modern pellet stove and verify their distribution in the solid, liquid and gaseous fractions of the fumes at the stack. In brief, the tests showed that about 85% of the harmful effect of PAH is associated with the PM. This confirms that special attention should be given to the control of the dust through a better design of the stoves and/or the development of abatement equipment also suitable for small devices.

12/01619 Modeling the atmospheric transport and outflow of polycyclic aromatic hydrocarbons emitted from China

Zhang, Y. *et al. Atmospheric Environment*, 2011, 45, (17), 2820–2827.

An Euler atmospheric transport model CanMETOP (Canadian model for environmental transport of organochlorine pesticides) was applied to the atmospheric transport and outflow of polycyclic aromatic hydrocarbons (PAHs) in China in 2003 based on a square kilometre resolution emission inventory. The reaction with OH radical, gas/particle partition by considering the adsorption onto total aerosol surface area, and dynamic soil/ocean–air exchange of PAHs were also considered. The results show that the spatial distribution of PAH concentration levels in the atmosphere is greatly controlled by emission and meteorological conditions. Elevated concentration levels are predicted in Shanxi, Guizhou, North China Plain, Sichuan Basin and Chongqing metropolitan areas due to the high emission densities at those locations. High concentrations are also modelled in environments offshore of China and in the western Pacific Ocean. The model also predicts a slightly decreasing vertical profile in the planetary boundary layer (lower than $\sim$1 km), but concentration decreases $\sim$2 orders of magnitude in the free atmosphere. The Westerlies as well as the East Asian Monsoon and local topographical forcings are identified as key factors influencing the transport pattern of PAHs in China. In 2003, $\sim$3800°tons of the 16 parent PAHs listed on USEPA priority control list were transported out of China with about 80% transported through the eastern boundary. The outflow concentrates near 30°N, signifying a slight discrepancy from the position of emission density peaks. The centre of the outflow plume is located at a height of $\sim$1 km at 120°E, and climbs to 3.5 km and 5 km at 130°E and 140°E, respectively. A seasonal variation of 5–6 fold is also found for the outflow flux with greatly elevated transport flux in spring and winter.

12/01620 Non-microbial methane emissions from fresh leaves: effects of physical wounding and anoxia

Wang, Z. *et al. Atmospheric Environment*, 2011, 45, (28), 4915–4921.

Non-microbial methane (CH_4) emissions from plants might be widespread in nature. However, this unexpected source and its global strength still remain controversial. Very recently it has been suggested that CH_4 release by plants may be linked to environmental stress. Using fresh leaves of 73 plants, including those from trees, shrubs and herbaceous species, a series of laboratory experiments have been employed to quantify CH_4 emissions and to examine the effect of physical wounding and anoxia. Approximately half of the plants investigated emitted CH_4 at rates >0.2 ng gdw^{-1}h^{-1}. Emissions from detached intact fresh leaves were in the ranges of 0.20–2.25 and 0.38–2.14 ng gdw^{-1}h^{-1} when incubated under air and anoxic conditions, respectively. Strongly enhanced emissions were monitored when leaves were physically wounded and/or incubated under anoxia. Several experiments were conducted to verify *in situ* emissions of CH_4 and exclude microbial activity as the source. Average short-lived pulsed CH_4 emissions of 53.4 ng gdw^{-1}h^{-1}, with a range of 0–687 ng gdw^{-1}h^{-1}, were observed from ground fresh leaves of the 60 plant species investigated, indicating that pulse emissions from plants immediately following environmental stress such as wounding need consideration to constrain global CH_4 emissions from vegetation. This type of emission may also assist with the delineation of the mechanism involved in non-microbial CH_4 formation.

Life cycle analysis

12/01621 A critical review of biochemical conversion, sustainability and life cycle assessment of algal biofuels

Singh, A. and Olsen, S. I. *Applied Energy*, 2011, 88, (10), 3548–3555.

The increasing global demand of biofuels for energy security and reduction in climate change effects generate the opportunity to explore new biomass sources. Algae is a very promising source of biomass in this context as it sequester a significant quantity of carbon from atmosphere and industrial gases and is also very efficient in utilizing the nutrients from industrial effluents and municipal wastewater. Therefore cultivation of algal biomass provide dual benefit, it provides biomass for the production of biofuels and also save the environment from air and water pollution. The life cycle assessment of algal biofuels suggests them to be environmentally better than the fossil fuels but economically it is not yet so attractive.

12/01622 A future bamboo-structure residential building prototype in China: life cycle assessment of energy use and carbon emission

Yu, D. *et al. Energy and Buildings*, 2011, 43, (10), 2638–2646.

In this study, the material-based energy use and carbon emission over the life cycle of a bamboo-structure residential building prototype with innovative insulation technologies are analysed. In comparison with a typical brick-concrete building, the bamboo-structure building requires less energy and emits less carbon dioxide to meet the identical functional requirements, i.e. envelope insulation and structure supporting. In order to systematically assess the energy use and carbon emission, several scenarios are designed based on the LEED standard and the technical potentials. The results indicate that there is a potential to reduce 11.0% (18.5%) of the embodied energy (carbon) for the use of recycled-content building materials and 51.3% (69.2%) for the recycling of construction and demolition waste, respectively. However, the practical effect of the potentials varies significantly depending on project management levels and available technologies in the current market. The analysis provides an insight into the assessment of the material-based energy use and carbon emission over the life cycle of a building.

12/01623 A LCA (life cycle assessment) of the methanol production from sugarcane bagasse

Grillo Renó, M. L. *et al. Energy*, 2011, 36, (6), 3716–3726.

Nowadays one of the most important environmental issues is the exponential increase of the greenhouse effect by the polluting action of the industrial and transport sectors. The production of biofuels is considered a viable alternative for the pollution mitigation but also to promote rural development. The work presents an analysis of the environmental impacts of the methanol production from sugarcane bagasse, taking into consideration the balance of the energy life cycle and its net environmental impacts, both are included in a life cycle assessment approach. The evaluation is done as a case study of a 100,000 t/year methanol plant, using sugarcane bagasse as raw material. The methanol is produced through the biomass to liquid route. The results of the environmental impacts were compared to other life cycle assessment studies of biofuel and it was showed that there are significant differences of environmental performance among the existing biofuel production system, even for the same feedstock. The differences are dependent on many factors such as farming practices, technology of the biomass conversion. With relation to the result of output/input ratio, the methanol production from sugarcane bagasse showed to be a feasible alternative for the substitution of an amount of fossil methanol obtained from natural gas.

12/01624 An evaluation of the life cycle cost of rapeseed oil as a straight vegetable oil fuel to replace petroleum diesel in agriculture

Baquero, G. *et al. Biomass and Bioenergy*, 2011, 35, (8), 3687–3697.

The use of straight vegetable oil (SVO) as biofuel has been recognized as a valid substitute of diesel fuel in the agricultural sector under specific circumstances. Its direct use reduces most of the chemical processes involved when converting it into biodiesel, thus lowering harmful emissions. This study presents the economic analysis of a self-supply farming model that uses rapeseed as its fuel base. This model addresses agricultural environmental concerns and can even minimize dependence on the fluctuating costs of diesel fuel. The use of SVO in agriculture can help reduce farmers' vulnerability to fossil fuel prices. The economic evaluation of the model proposed in this study shows clear economic benefits of introducing rapeseed to the traditional crop rotation of wheat and barley. The key factors analysed in this model are diesel fuel price, diesel fuel grants and crop aids. The current situation in Spain favours the use of diesel fuel in agriculture rather than rapeseed SVO due to an 8% profit difference. However, results show that changes in key factors slightly affect the profit margin, calculating a difference of only 3.7% for particular factor combinations. Combined environmental-friendly agriculture supporting policies are necessary to cover this slight profit difference to promote this biofuel.

12/01625 Assessment of a stand-alone gradual capacity reverse osmosis desalination plant to adapt to wind power availability: a case study

Peñate, B. *et al. Energy*, 2011, 36, (7), 4372–4384.

Desalination driven by renewable energies is an interesting technology in isolated coastal areas. Its feasibility and reliability are guaranteed by innumerable designs implemented and experiences carried out, mainly focused on small capacity systems. However, only mature and efficient technologies are suitable for medium or large scale desalination. In the case of seawater desalination, wind-powered reverse osmosis is the most efficient, mature and cost-effective technology. This paper assesses the most suitable design for seawater reverse osmosis desalination driven by off-grid wind energy systems. A high innovative design based on gradual capacity with nominal production of 1000 m^3/day is compared to a conventional fixed capacity desalination plant. Due to the intermittent wind resource, the gradual capacity desalination plant is able to fit the available energy and maximize the annual water production.

12/01626 Basic building life cycle calculations to decrease contribution to climate change – case study on an office building in Sweden

Wallhagen, M. *et al. Building and Environment*, 2011, 46, (10), 1863–1871.

This study examined whether simplified life cycle-based calculations of climate change contributions can provide better decision support for building design. Contributions to climate change from a newly built office building in Gävle, Sweden, were studied from a life cycle perspective as a basis for improvements. A basic climate and energy calculation tool for buildings developed in the European project ENSLIC was used. The study also examined the relative impacts from building material production and building operation, as well as the relative importance of the impact contributions from these two life cycle stages at various conditions. The ENSLIC tool calculates operational energy use and contributions to climate change of a number of optional improvement measures. Twelve relevant improvement measures were tested. The most important measures proved to be changing to CO_2 free electricity, changing construction slabs from concrete to wood, using windows with better U-values, insulating the building better and installing low-energy lighting and white goods. Introduction of these measures was estimated to reduce the total contribution to climate change by nearly 50% compared with the original building and the operational energy use by nearly 20% (from 100 to 81 kWh/m^2 year). Almost every building is unique and situated in a specific context. Making simple analyses of different construction options showed to be useful and gave some unexpected results which were difficult to foresee from a general design experience. This process acts as an introduction to life cycle thinking and highlights the consequence of different material choices.

12/01627 Energy life cycle assessment of rice straw bio-energy derived from potential gasification technologies

Shie, J.-L. *et al. Bioresource Technology*, 2011, 102, (12), 6735–6741.

To be a viable alternative, a biofuel should provide a net energy gain and be capable of being produced in large quantities without reducing food supplies. Amounts of agricultural waste are produced and require treatment, with rice straw contributing the greatest source of such potential bio-fuel in Taiwan. Through life-cycle accounting, several energy indicators and four potential gasification technologies (PGT) were evaluated. The input energy steps for the energy life cycle assessment (ELCA) include collection, generator, torrefaction, crushing, briquetting, transportation, energy production, condensation, air pollution control and distribution of biofuels to the point of end use. Every PGT has a positive energy benefit. The input of energy required for the transportation and pre-treatment are major steps in the ELCA. On-site briquetting of refused-derived fuel (RDF) provides an alternative means of reducing transportation energy requirements. Bio-energy sources, such as waste rice straw, provide an ideal material for the bio-fuel plant.

12/01628 Fuel life cycle emissions for electricity consumption in the world's gaming center – Macao SAR, China

To, W. M. *et al. Energy*, 2011, 36, (8), 5162–5168.

The gaming and hospitality sector has been expanding rapidly in recent years. Concurrently energy consumption in this sector has surged significantly. This paper reviews the literature on the relationship between electricity consumption and economic growth and introduces the four-parameter logistic functions to model the growth of electricity consumption and other related parameters in the world's gaming centre – Macao, China. The accuracy of the growth models were assessed by using the mean absolute percentage error and the root mean squared percentage error. The paper also introduces the application of life cycle analysis to greenhouse gases emissions for electricity consumption. As Macao in recent years has imported a significant amount of electricity from a coal-fired power plant in nearby Zhuhai, the impact analysis included greenhouse gases emissions from the extraction, transportation, processing, and combustion along fuel life cycles in the local power plant as well as Zhuhai's power plant. It was found that the emissions associated with the imported electricity contributed greatly to total emissions.

12/01629 Incorporating uncertainty analysis into life cycle estimates of greenhouse gas emissions from biomass production

Johnson, D. R. *et al. Biomass and Bioenergy*, 2011, 35, (7), 2619–2626.

Before further investments are made in utilizing biomass as a source of renewable energy, both policy makers and the energy industry need estimates of the net greenhouse gas (GHG) reductions expected from substituting biobased fuels for fossil fuels. Such GHG reductions depend greatly on how the biomass is cultivated, transported, processed, and converted into fuel or electricity. Any policy aiming to reduce GHGs with biomass-based energy must account for uncertainties in emissions at each stage of production, or else it risks yielding marginal reductions, if any, while potentially imposing great costs. This paper provides a framework for incorporating uncertainty analysis specifically into estimates of the life cycle GHG emissions from the production of biomass. The authors outline the sources of uncertainty, discuss the implications of uncertainty and variability on the limits of life cycle assessment models, and provide a guide for practitioners to best practices in modelling these uncertainties. The suite of techniques described herein can be used to improve the understanding and the representation of the uncertainties associated with emissions estimates, thus enabling improved decision making with respect to the use of biomass for energy and fuel production.

12/01630 Integrated life-cycle design of building enclosures

Mora, R. *et al. Building and Environment*, 2011, 46, (7), 1469–1479.

In spite of the progress in developing methods and tools to support sustainable building design, there is still a lack of a formal approach to bridge the 'no man's land' gap between the traditional building engineering disciplines, and between these and the architecture, to achieve the level of building integration required for sustainability. This paper presents an integration framework that aims at facilitating the inclusion of life-cycle considerations in the design process from the outset, so that materials and systems are selected not only from environmentally friendly resources, but most importantly, to match service life performance expectations. The framework describes an iterative methodology to evaluate these expectations in practice, which is based on an understanding and modelling of the dynamics of the built environment to which materials, components, and systems are exposed. Quantitative methods and test protocols can be incorporated into the framework for assessing function-performance aspects of alternative solutions. Due to its complexity stemming from its inherent exposure to variable environmental loads and its multi-functionality, the framework focuses on addressing the life cycle of the building enclosure system. It is expected that the organization of the underlying principles of building life-cycle performance described in this paper will become a knowledge core that will facilitate a more integrated treatment of buildings in research, education, and practice.

12/01631 Life cycle assessment of a micromorph photovoltaic system

Bravi, M. *et al. Energy*, 2011, 36, (7), 4297–4306.

In this paper, the results from an in-depth life cycle analysis of production and use of a novel grid-connected photovoltaic micromorph system are presented and compared to other thin film and traditional crystalline silicon photovoltaic technologies. Among the new thin film technologies, the micromorph tandem junction appears to be one of the most promising devices from the industrial point of view. The analysis was based on actual production data given to the authors directly from the PRAMAC Swiss company and it is consistent with the recommendations provided by the ISO norms and updates. The gross energy requirement, greenhouse gas emissions and energy pay-back time have been calculated for the electric energy output virtually generated by the studied system in a lifetime period of 20 years. A comparative framework is also provided, wherein results obtained for the case study are compared with data from literature previously obtained for the best commercially available competing photovoltaic technologies. Results clearly show a significant decrease in gross energy requirement, in greenhouse gas emissions and also a shorter energy pay-back time for the micromorph technology.

12/01632 Life cycle assessment of biodiesel production using alkali, soluble and immobilized enzyme catalyst processes

Raman, J. K. *et al. Biomass and Bioenergy*, 2011, 35, (10), 4221–4229.

This study deals with the life cycle assessment (LCA) of three different catalytic processes for biodiesel production. In the LCA study, a 'cradle to gate' approach was adopted to estimate the environmental impact of different catalytic processes such as immobilized, soluble biocatalyst and alkali catalyst. The results revealed that, biodiesel production using immobilized biocatalyst has less environmental impact compared to alkali and soluble biocatalyst. The environmental impact of the immobilized biocatalyst depends on the reusability factor.

12/01633 Life cycle assessment of biogas infrastructure options on a regional scale

Patterson, T. *et al. Bioresource Technology*, 2011, 102, (15), 7313–7323.

A life cycle assessment has been completed of potential biogas infrastructures on a regional scale. Centralized and distributed infrastructures were considered along with biogas end uses of combined heat and power (CHP) and injection to the gas grid for either transport fuel or domestic heating end uses. Damage orientated (endpoint) life cycle impact assessment method identified that CHP with 80% heat utilization had the least environmental impact, followed by transport fuel use. Utilization for domestic heating purposes via the gas grid was found to perform less well. A 32% difference in transportation requirement between the centralized and distributed infrastructures was found to have a relatively small effect on the overall environmental impact. Global warming impacts were significantly affected by changes in methane emissions at upgrading stage, highlighting the importance of minimizing operational losses.

12/01634 Life cycle assessment of small-scale high-input Jatropha biodiesel production in India

Pandey, K. K. *et al. Applied Energy*, 2011, 88, (12), 4831–4839.

In the current scenario of depleting energy resources, increasing food insecurity and global warming, Jatropha has emerged as a promising energy crop for India. The aim of this study is to examine the life cycle energy balance for Jatropha biodiesel production and greenhouse gas emissions from post-energy use and end combustion of biodiesel, over a period of 5 years. This a case-specific study for a small scale, high input Jatropha biodiesel system. Most of the existing studies have considered low input Jatropha biodiesel system and have used net energy balance (NEB), i.e. difference of energy output and energy input, and net energy ratio (NER), i.e. ratio of energy output to energy input, as indicators for estimating the viability of the systems. Although, many of them have shown these indicators to be positive, yet the values are very less. The results of this study, when compared with two previous studies of Jatropha, show that the values for these indicators can be increased to a much greater extent, if a high input Jatropha biodiesel system is used. Further, when compared to a study done on palm oil and Coconut oil, it was found even if the NEB and NER of biodiesel from Jatropha were lesser in comparison to those of palm oil and coconut oil, yet, when energy content of the co-products were also considered, Jatropha had the highest value for both the indicators in comparison to the rest two.

12/01635 Life cycle assessment of SNG from wood for heating, electricity, and transportation

Steubing, B. *et al. Biomass and Bioenergy*, 2011, 35, (7), 2950–2960.

The conversion of wood to synthetic natural gas (SNG) via gasification and catalytic methanation is a renewable close to commercialization technology that could substitute fossil fuels and alleviate global warming. In order to assure that it is beneficial from the environmental perspective, a cradle to grave life cycle assessment (LCA) of SNG from a first-of-its-kind polygeneration unit for heating, electricity generation, and transportation was conducted. These SNG systems were compared to fossil and conventional wood reference systems and environmental benefits from their substitution evaluated. Finally, sensitivity analysis is conducted for expected technological improvements and factors that could decrease environmental performance. It is shown that substituting fossil technologies with SNG systems is environmentally beneficial with regard to global warming and for selected technologies also with regard to aggregated environmental impacts. On the condition that process heat is used efficiently, technological improvements such as increased efficiency and denitrification could further increase this advantage. On the other hand, lower GHG emissions and aggregated impacts are partly compensated by other environmental effects, e.g. eutrophication, ecotoxicity, and respiratory disease caused by inorganics. Since more efficient alternatives exist for the generation of heat and electricity from wood, it is argued that SNG is best used for transportation. In the light of a growing demand for renewable transportation fuels and commercial scale technological development being only in its initial stage, the production of SNG from wood seems to be a promising technology for the near future.

12/01636 Life cycle assessment of two palm oil production systems

Stichnothe, H. and Schuchardt, F. *Biomass and Bioenergy*, 2011, 35, (9), 3976–3984.

In 2009 approximately 40 Mt of palm oil were produced globally. Growing demand for palm oil is driven by an increasing human population as well as subsidies for biodiesel and is likely to increase further in coming years. The production of 1 t crude palm oil requires 5 t of fresh fruit bunches (FFB). On average processing of 1 t FFB in palm oil mills generates 0.23 t empty fruit bunches (EFB) and 0.65 t palm oil mill effluents (POME) as residues. In this study it is assumed that land use change does not occur. In order to estimate the environmental impacts of palm oil production a worst and a best case scenario are assessed and compared in the present study using 1000 kg of FFB as functional unit. The production and treatment of 1 t of FFB causes more than 460 kg CO_{2eq} in the worst-case scenario and 110 kg CO_{2eq} in the best-case scenario. The significant greenhouse gas (GHG) emission reduction is achieved by co-composting residues of the palm oil mill. Thus treating those residues appropriately is paramount for reducing environmental impacts particularly global warming potential (GWP) and eutrophication potential (EP). Another important contributor to the EP but also to the human toxicity potential (HTP) is the biomass powered combined heat and power (CHP) plant of palm oil mills. Frequently CHP plants of palm oil mills operate without flue gas cleaning. The CHP plant emits heavy metals and nitrogen oxides and these account for 93% of the HTP of the advanced palm oil production system, of which heavy metal emissions to air are responsible for 79%. The exact emission reduction potential from CHP plants could not be quantified due to existing data gaps, but it is apparent that cleaning the exhaust gas would reduce eutrophication, acidification and toxicity considerably.

12/01637 Life cycle cost analysis of a multi-storey residential net zero energy building in Denmark

Marszal, A. J. and Heiselberg, P. *Energy*, 2011, 36, (9), 5600–5609.

It is well recognized that in the long run, the implementation of energy efficiency measures is a more cost-optimal solution in contrast to taking no action. However, the net zero-energy building (ZEB) concept raises a new issue: how far should we go with energy efficiency measures and when should we start to apply renewable energy technologies? This analysis adopts the life cycle cost methodology and uses a multi-family net ZEB to find the answer to this question. Moreover, it looks at the issue from the building owner's perspective, hence it should be seen as a private economy analysis. The study includes three levels of energy demand and three alternatives of energy supply systems: (1) photovoltaic installation with photovoltaic/solar thermal collectors and an ambient air/solar source heat pump; (2) photovoltaic installation with a ground-source heat pump; (3) photovoltaic installation with district heating grid. The results indicate that in order to build a cost-effective net ZEB, the energy use should be reduced to a minimum leaving just a small amount of left energy use to be covered by renewable energy generation. Moreover, from the user perspective in the Danish context, the district heating grid is a more expensive source of heat than a heat pump for the net ZEB.

12/01638 Life cycle energy and CO_2 analysis of microalgae-to-biodiesel: preliminary results and comparisons

Khoo, H. H. *et al. Bioresource Technology*, 2011, 102, (10), 5800–5807.

Despite claims that microalgal biofuels are environmentally friendlier alternatives to conventional fuels, debate surrounding its ecological benefits or drawbacks still exists. LCA is used to analyse various biofuel production technologies from 'cradle to gate'. Energy and CO_2 balances are carried out for a hypothetical integrated PBR-raceway microalgae-to-biodiesel production in Singapore. Based on a functional unit of 1 MJ biofuel, the total energy demands are 4.44 MJ with 13% from biomass production, 85% from lipid extraction, and 2% from biodiesel production. Sensitivity analysis was carried out for adjustments in energy requirements, percentage lipid contents, and lower/higher heating product value. An 'optimistic case' was projected with estimates of: 45% lipid content; reduced energy needs for lipid extraction (1.3 MJ per MJ biodiesel); and heating value of biodiesel (42 MJ/kg). The life cycle energy requirements dropped significantly by about 60%. The results are compared with other published case studies from other countries.

12/01639 Lifecycle assessment of the economic, environmental and energy performance of *Jatropha curcas* L. biodiesel in China

Wang, Z. *et al. Biomass and Bioenergy*, 2011, 35, (7), 2893–2902.

Due to issues relating to the sustainability of biofuel production, second generation biofuel has attracted much attention. As a promising feedstock of second generation biodiesel, *Jatropha curcas* L. (JCL) is being massively planted on marginal land in China, but its viability as a biofuel source has not been systematically assessed. This paper performed a lifecycle assessment of the economic, environmental and energy (3E) performance of the JCL biodiesel, assuming JCL oil is either used for direct blending with diesel or further processed into JCL methyl ester (JME). The results show that, at the current technical levels, the production of JCL biodiesel is financially infeasible, but has positive environmental and energy performance. Despite the additional cost incurred in the transesterification process, the net present value of JME is slightly higher than that of JCL oil when a part of the cost is allocated to the co-product, i.e. glycerin. As compared with that of diesel, the production and consumption of per litre JCL oil and JME can reduce 7.34 kg and 8.04 kg CO_2 equivalent, respectively. The energy balances of both JCL oil and JME are 1.57 and 1.47, respectively, in terms of the ratio of the heat value of biodiesel and that of energy input. The main factors affecting the 3E performance of JCL biodiesel are seed yield, co-product output, and farm energy input.

12/01640 Multi-objective optimization minimizing cost and life cycle emissions of stand-alone PV–wind–diesel systems with batteries storage

Dufo-López, R. *et al. Applied Energy*, 2011, 88, (11), 4033–4041.

This paper describes an application of the strength pareto evolutionary algorithm to the multi-objective optimization of a stand-alone PV–wind–diesel system with batteries storage. The objectives to be minimized are the levelized cost of energy (LCOE) and the equivalent carbon dioxide (CO_2) life cycle emissions (LCE). Each solution of the Pareto front is a possible solution for the PV–wind–diesel-batteries system, which can supply the load, but each one has a different LCOE and LCE. Some solutions have low LCOE values, but high LCE values, and vice versa. Results show that the photovoltaic (PV) generator is the most important source of electrical energy for stand-alone systems in Spain and southern Europe, not only environmentally, but also economically. In some cases, PV is almost the only source of energy, as some solutions of the best Pareto front do not include wind turbines and diesel generators run only a few hours during the year.

12/01641 Thermo-economic analysis of pipe insulation for district heating piping systems

Keçebaş, A. *et al. Applied Thermal Engineering*, 2011, 31, (17–18), 3929–3937.

In this study, the optimum insulation thickness of pipes used in district heating pipeline networks, energy savings over a lifetime of 10 years, and payback periods are calculated for the five different pipe sizes and four different fuel types in the city of Afyonkarahisar in Turkey. For this reason, an optimization model is performed depending on life cycle cost analysis via P_1–P_2 method. Rock wool as insulation material and a system of pipelines (50–200 mm nominal sizes) with flow of hot water are considered. The results show that optimum insulation thicknesses vary between 0.085 and 0.228 m, energy savings vary between 10.041 \$/m and 175.171 \$/m, and payback periods vary between 0.442 and 0.808 years depending on the nominal pipe sizes and the fuel types. The highest value of energy savings is reached in 250 mm nominal pipe size for fuel-oil fuel type, while the lowest value is obtained in 50 mm for geothermal energy. Considering the economic and environmental advantages, the geothermal energy is a better choice and then natural gas.

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Supplies, policy, economics, forecasts

12/01642 A general source-sink model with inoperability constraints for robust energy sector planning

Tan, R. R. *Applied Energy*, 2011, 88, (11), 3759–3764.

The concept of inoperability was originally introduced as a means of quantifying risk in systems comprised of interdependent subsystems, using a modified input–output framework. This paper describes a novel robust optimization model for energy planning with inoperability constraints. The formulation is based on the established source-sink framework, which has been used extensively for energy planning applications under various environmental footprint constraints. The proposed model determines the optimal allocation of various energy sources within a system to corresponding energy sinks or demands, while ensuring that inoperability limits of the latter are satisfied for multiple enumerated scenarios. The basic formulation results in a linear program, while a mixed integer linear programming extension is also described. In either case, a globally optimal solution can be easily determined if one exists. Illustrative case studies are then given to demonstrate this new method.

12/01643 A roadmap towards intelligent net zero- and positive-energy buildings

Kolokotsa, D. *et al. Solar Energy*, 2011, 85, (12), 3067–3084.

Buildings nowadays are increasingly expected to meet higher and more complex performance requirements: they should be sustainable; use zero-net energy; foster a healthy and comfortable environment for the occupants; be grid-friendly, yet economical to build and maintain. The essential ingredients for the successful development and operation of net zero- and positive-energy buildings (NZEB/PEB) are: thermal simulation models, that are accurate representations of the building and its subsystems; sensors, actuators, and user interfaces to facilitate communication between the physical and simulation layers; and finally, integrated control and optimization tools of sufficient generality that using the sensor inputs and the thermal models can take intelligent decisions, in almost real-time, regarding the operation of the building and its subsystems. To this end the aim of the present paper is to present a review on the technological developments in each of the essential ingredients that may support the future integration of successful NZEB/PEB, i.e. accurate simulation models, sensors and actuators and last but not least the building optimization and control. The integration of the user is an integral part in the dynamic behaviour of the system, and this role has to be taken into account. Future prospects and research trends are discussed.

12/01644 An energy balance and greenhouse gas profile for county Wexford, Ireland in 2006

Curtin, R. *Applied Energy*, 2011, 88, (11), 3773–3781.
In this paper an energy balance and a greenhouse gas profile has been formulated for the county of Wexford, situated in south-east Ireland. The energy balance aims to aggregate all energy consumption in the county for the year 2006 across the following sectors; residential, agriculture, commerce and industry, and transport. The results of the energy balance are compared with the previous energy balance of 2001 where it is found that the residential sector is the biggest emitter of CO_2 with 38% of total emissions with the transport and industry/commerce sectors sharing second place on 28%. Consumption of oil is seen to have increased significantly in nearly all sectors, accounting for over 70% of the total final energy consumed (TFC) while the total primary energy requirement (TPER) sees oil consumption accounting for 91% of all fuels consumed. To take into account the contribution of agriculture in total greenhouse gas (GHG) emissions the gases CH_4 and N_2O will be estimated from the agricultural and waste sectors. The results show that methane contributes 25% of total GHG emissions with agriculture being the primary contributor accounting for 36% of total emissions.

12/01645 An outlook of Malaysian energy, oil palm industry and its utilization of wastes as useful resources

Sulaiman, F. *et al. Biomass and Bioenergy*, 2011, 35, (9), 3775–3786.
Malaysia has an abundance of energy resources, both renewable and non-renewable. The largest non-renewable energy resource found in Malaysia is oil, and second, is natural gas, primarily liquefied natural gas. The production and consumption of oil, gas and coal in Malaysia are given in this paper. The energy demand and supply by source are also shown in relation to the country's fuel diversification policy. In order to reduce the overall dependence on a single source of energy, efforts were undertaken to encourage the utilization of renewable resources. Forest residue and oil palm biomass are found to be potentially of highest energy value and considered as the main renewable energy option for Malaysia. Palm oil and related products represent the second largest export of Malaysia. The total oil palm planted area in Malaysia has increased significantly in recent years. This paper gives a detailed representation of oil palm planted and produced together with its yield from the year 1976 onwards. The large amounts of available forest and palm oil residues resulting from the harvest can be utilized for energy generation and other by-products in a manner that also addresses environmental concerns related to current waste disposal methods.

12/01646 Causal relationship between energy consumption (EC) and GDP: a Markov-switching (MS) causality

Fallahi, F. *Energy*, 2011, 36, (7), 4165–4170.
This paper re-examines the causal relationship between energy use and gross domestic product (GDP) in the USA for the period 1960–2005. To that end, Markov-switching vector autoregressive (MS-VAR) models are used, rather than vector autoregressive (VAR) models, which allows for regime shifts. These models are capable of detecting changes in the relationship between variables; in addition, the coefficients of the model are time dependent and they depend on the states of the variables. Therefore, in contrast to VAR and vector error correction models (VECM), which assume a stable relationship, the relationship between the variables could be different in the separate regimes. Results from the estimation of MS models show changes in the pattern of causality relationship between GDP and energy use. That is, evidence of bidirectional Granger causality (GC) is found between the variables in the first regime, while there is no GC between the variables in the second regime. The first regime consists of 1971–1975, 1977–1982, 1989–1995, and from 2001 to the end of the sample. This regime includes the energy crises in 1970s, the recessions in the early 1980s, 1990s, and the recession in 2001.

12/01647 Characterization of the household electricity consumption in the EU, potential energy savings and specific policy recommendations

de Almeida, A. *et al. Energy and Buildings*, 2011, 43, (8), 1884–1894.
Although significant improvements in energy efficiency have been achieved in home appliances and lighting, the electricity consumption in the European Union (EU) household has increased by 2% per year during the past 10 years. Some reasons are associated with an increased degree of basic comfort and level of amenities and with the widespread utilization of new types of loads. Wishing to increase the understanding of the energy consumption in the EU households for the different types of equipment including the consumers' behaviour and comfort levels, and to identify demand trends, an energy monitoring campaign, was carried out in 12 geographically representative EU countries, accompanied by a lifestyle survey. From the measurements carried out it was concluded that Information Technologies and entertainment loads are key contributors to the power demand. In basically all types of loads there is wide range of performance levels in the models available in the market. Available technology, associated with responsible consumer behaviour, can reduce wasteful consumption. Based on a bottom-up approach the European residential sector potential electricity savings that can be implemented by existing technologies and improved behaviour can reach 48%. The paper presents policy recommendations promoting market transformation and behavioural changes in the equipment selection and operation.

12/01648 Conceptualizing and measuring energy security: a synthesized approach

Sovacool, B. K. and Mukherjee, I. *Energy*, 2011, 36, (8), 5343–5355.
This article provides a synthesized, workable framework for analysing national energy security policies and performance. Drawn from research interviews, survey results, a focused workshop, and an extensive literature review, this article proposes that energy security ought to be comprised of five dimensions related to availability, affordability, technology development, sustainability, and regulation. The authors then break these five dimensions down into 20 components related to security of supply and production, dependency, and diversification for availability; price stability, access and equity, decentralization, and low prices for affordability; innovation and research, safety and reliability, resilience, energy efficiency, and investment for technology development; land use, water, climate change, and air pollution for sustainability; and governance, trade, competition, and knowledge for sound regulation. Further still, the synthesis lists 320 simple indicators and 52 complex indicators that policymakers and scholars can use to analyse, measure, track, and compare national performance on energy security. The article concludes by offering implications for energy policy more broadly.

12/01649 Determination of strategic adaptation actions for public housing in Singapore

Teo, E. A. L. and Lin, G. *Building and Environment*, 2011, 46, (7), 1480–1488.
Although building adaptation finds it significant in combating building deterioration and delivering building sustainability, what level of adaptation a building shall receive always seems puzzling to property portfolio managers. This research aims to provide policy makers with a theoretical approach to choose strategically desired adaptation actions for buildings. Personal interviews with policy makers in Singapore public housing sector gave rise to the construction of an attribute-action database; this database was used to derive an attribute-action matrix, which consists of a set of preference values for each adaptation action (i.e. retaining, renovating and rebuilding). This approach was then applied to a real public residential building in Singapore. The results show that the total preference values for the actions of retaining, renovating and rebuilding are 157.849, 111.609, and 90.575, respectively; the action of retaining with minor maintenance of building facades is found to be the most desired adaptation strategy for the case building, because compared with the other two, retaining has the maximum total preference value. The presented approach would therefore extend the understanding of how strategic adaptation actions can be made for existing buildings that require adaptation. Lessons learnt in Singapore public housing context may be useful for many other cities in face of similar problems.

12/01650 Economical assessment of different HVAC systems for an operating room: case study for different Turkish climate regions

Ozyogurtcu, G. *et al. Energy and Buildings*, 2011, 43, (7), 1536–1543.
In this study, the annual energy consumptions of four different heating, ventilation and air conditioning (HVAC) systems serving to operation rooms (ORs) located at five different cities (Izmir, Antalya, Istanbul, Ankara and, Erzurum) in Turkey are analysed. The study is performed for four different HVAC systems: (a) 100% fresh air system (System I), (b) 100% fresh air with half air volume rate at night period (System II), (c) 100% fresh air with half air volume rate at night period and heat recovery unit (System III), (d) 50% fresh air with half air volume rate at night period and with heat recovery and mixing units (System IV). Life cycle cost (LCC) for 20 years life span is calculated for the considered systems. It is found that System IV considerably reduces energy consumption and it is economically proper for the considered cities. The rate of energy consumption and LCC reductions are greater for the cities with extreme climate condition having relatively low

specific humidity ratio. Using System IV instead of System I reduces OR energy consumption by 74% for the city of Erzurum which has a cold and dry climate.

12/01651 Energy demand projection of China using a path-coefficient analysis and PSO–GA approach

Yu, S. *et al*. *Energy Conversion and Management*, 2012, 53, (1), 142–153.

Energy demand projection is fundamental to rational energy planning formulation. The present study investigates the direct and indirect effects of five factors, namely GDP, population, proportion of industrial, proportion of urban population and coal percentage of total energy consumption on China's energy demand, implementing a path-coefficient analysis. On this basis, a hybrid algorithm, particle swarm optimization and genetic algorithm optimal energy demand estimating (PSO–GA EDE) model, is proposed for China. The coefficients of the three forms of the model (linear, exponential and quadratic model) are optimized by proposed PSO–GA. To obtain a combinational prediction of three forms, a departure coefficient method is applied to get the combinational weights. The results show that the China's energy demand will be 4.48 billion tce in 2015. Furthermore; the proposed method forecast shows its superiority compared with other single optimization method such as GA, PSO or ACO and multiple linear regressions.

12/01652 Estimating the supply and demand of gasoline using tax data

Coyle, D. *et al*. *Energy Economics*, 2012, 34, (1), 195–200.

This paper estimates supply and demand functions for the US gasoline market using information from excise tax returns provided by the IRS for the period 1990–2009. Price and income elasticities are found of demand similar to those found using EIA data. A price elasticity of supply of 0.29 is found, which differs from the common assumption of a perfectly inelastic short-run supply curve. By using a novel data source, the analysis provides a robustness check of aggregate studies of gasoline demand and a consistent, econometric estimate of the price elasticity of gasoline supply. The results are useful in guiding tax and regulatory policies regarding gasoline consumption.

12/01653 Forecasting future oil demand in Iran using GSA (gravitational search algorithm)

Behrang, M. A. *et al*. *Energy*, 2011, 36, (9), 5649–5654.

Growing energy demand of the world, made the major oil and gas exporting countries to have critical role in the energy supply. The geostrategic situation of Iran and its access to the huge hydrocarbon resources placed the country among important areas and resulted in the investment development of oil and gas industry. In this study, a novel approach for oil consumption modelling is presented. Three demand estimation models are developed to forecast oil consumption based on socio-economic indicators using gravitational search algorithm (GSA). In first model (PGIE) oil consumption is estimated based on population, GDP, import and export. In second model (PGML) population, GDP, export minus import, and number of LDVs (light-duty vehicles) are used to forecast oil consumption and in third one (PGMH) population, GDP, export minus import, and number of HDVs (heavy-duty vehicles) are used to estimate oil consumption. Linear and non-linear forms of equations are developed for each model. In order to show the accuracy of the algorithm, a comparison is made with the genetic algorithm and particle swarm optimization estimation models which are developed for the same problem. Oil demand in Iran is forecasted up to year 2030.

12/01654 Growing trade of bioenergy in the EU: public acceptability, policy harmonization, European standards and certification needs

Magar, S. B. *et al*. *Biomass and Bioenergy*, 2011, 35, (8), 3318–3327.

Since 2000, the consumption of bioenergy in the European Union (EU) has grown, along with a concurrent growth in the trade of biomass for energy purposes (though traded volumes still remain small). Bioenergy production and trade will likely continue to increase into the future, driven by climate change concerns, emissions reduction targets, increasing concerns about domestic energy security and favourable policies. The harmonization of European standards and the development of certification systems are key issues to resolving potential negative effects of increased biomass trade. Certification systems not only address the issue of environmental sustainability from production to end-use, but also allow for product differentiation while adding value to sustainably produced products, which can ultimately enhance a competitive and sustainable bioenergy market. In addition to analysing bioenergy trade growth in the EU, a questionnaire survey of 92 bioenergy experts from eight member states within the EU was conducted. Survey results show that bioenergy is highly accepted in the EU but that there is a lack of European standards and policy harmonization, along with the absence of a competitive market or a certification system, all of which are necessary for sustainable production and trade of bioenergy. A large majority (63%) of the total respondents agreed that the certification of bioenergy is necessary to promote the sustainable use of biomass.

12/01655 India's energy needs and low carbon options

Parikh, J. and Parikh, K. *Energy*, 2011, 36, (6), 3650–3658.

India's aspiration for economic growth has consequences for energy growth and CO_2 emissions. This paper examines India's need for energy with 20 year perspectives. Demand scenarios are examined from the supply perspectives ranging from coal, hydrocarbon, nuclear, hydrogen, hydro and other renewable, etc. None of these are substantial and India will have to rely on imports. The need for energy has to be reduced by a drive for energy efficiency and renewable energy. Government programmes for the above are also commented upon. Though India's CO_2 emissions are unlikely to grow very much due to energy scarcity and energy mix the article examines the potential to reduce CO_2 emissions and the associated costs involved in various options. It finds that 30% reduction in CO_2 emissions by 2030 is feasible but would involve additional costs. The most promising option is to reduce energy demand by various measures to increase energy use efficiency in production and consumption.

12/01656 Local energy policies for Kyoto goals: *Ecoabita protocol* a key action to reduce energy consumption in residential sector

Bizzarri, G. *Energy and Buildings*, 2011, 43, (9), 2394–2403.

This article focuses on the results obtained by the enforcement of an original greenhouse gas emissions policy, issued in recent years in several municipalities in northern Italy. The municipality of Reggio Emilia was one of the firsts in Italy to develop and adopt a voluntary building energy-consumption certification method called Ecoabita, aiming to promote energy efficiency in buildings over its jurisdiction. Several reasons make this project innovative: first, the certification method has been processed through and verified by a quality international agency, secondly the procedure is assisting financial-incentive policies both on mandatory (European Directive 2002/91/CE) and voluntary basis (Municipality Protocol Ecoabita), finally it allows to obtain eligible credits for avoided emissions that can be negotiated on the CO_2 exchange market. With specific reference to Reggio Emilia case, acknowledged the amount of actions, that are normally scheduled in the municipality throughout a year, it has been evaluated the benefit, in terms of environmental improvement, descended from the protocol, also projecting their trend in future years up to 2020 as well, demonstrating the scheduled interventions are fundamental in sought of the achievement of the Kyoto and Copenhagen commitments. The entire procedure has been developed in accordance to the parameters given by UNFCCC for these kinds of analyses and has been recently confirmed to be one of the most accurate international accounting procedure by a survey developed by the scientific committee of the European Project LIFE-LAKS.

12/01657 Longitudinal prediction of the operational energy use of buildings

de Wilde, P. *et al*. *Building and Environment*, 2011, 46, (8), 1670–1680.

Thus far most studies of operational energy use of buildings fail to take a longitudinal view, or in other words, do not take into account how operational energy use changes during the lifetime of a building. However, such a view is important when predicting the impact of climate change, or for long-term energy accounting purposes. This article presents an approach to deliver a longitudinal prediction of operational energy use. The work is based on the review of deterioration in thermal performance, building maintenance effects, and future climate change. The key issues are to estimate the service life expectancy and thermal performance degradation of building components while building maintenance and changing weather conditions are considered at the same time. Two examples are presented to demonstrate the application of the deterministic and stochastic approaches, respectively. The work concludes that longitudinal prediction of operational energy use is feasible, but the prediction will depend largely on the availability of extensive and reliable monitoring data. This premise is not met in most current buildings.

12/01658 Modeling the relationship between energy consumption and economy development in China

Zhang, J. *et al*. *Energy*, 2011, 36, (7), 4227–4234.

This paper investigated the empirical relationship between economy development and energy consumption by material production, non-material production and household. Empirical models accounting for the key influential factors were constructed. Ordinary least square regression (OLS) analysis of the official data of China for the year 1985–2007 permitted the relationship between individual energy consumption components and the corresponding coefficients to be investigated. The results showed that (1) the unit energy consumption by primary industry, secondary industry, and tertiary industry demonstrated an inverse relationship with gross domestic product (GDP); (2) a linear relationship exists between the energy consumption by non-material production and GDP; (3) the hypotheses that there is an inverse S-shaped relationship between unit energy consumption by household and personal income is valid. Based on the above findings and an analysis of China's energy policies, suggestions on China's energy policy were given in the end.

12/01659 Read the label! Energy Star appliance label awareness and uptake among U.S. consumers

Murray, A. G. and Mills, B. F. *Energy Economics*, 2011, 33, (6), 1103–1110.

The Energy Star label program to promote the diffusion of energy efficient home appliances is arguably the most significant government effort to reduce US residential energy consumption. Program effectiveness requires that consumers are aware of the labelling scheme and also change their purchase decisions based on label information. This paper examines the factors associated with consumer awareness of the Energy Star label of recently purchased 'white' major appliances and the factors associated with the choice of Energy Star labelled appliances. The paper finds that household characteristics have a much stronger association with consumer awareness of labels than with the choice of Energy Star appliances. Renting the home, Hispanic ethnicity, being poor or near poor, and living in regions with lower ACEEE scores do, however, decrease the propensity for households to purchase Energy Star appliances. Eliminating these gaps in Energy Star appliance adoption would result in house electricity cost savings of $164 million per year and associated carbon emission reductions of about 1.1 million tonnes per year.

12/01660 Recommendations for implementation of energy strategy of the Republic of Croatia

Sedlar, D. K. *et al. Energy*, 2011, 36, (7), 4191–4206.

The energy strategy of the Republic of Croatia was adopted by the Croatian parliament in 2009 for the period until 2020 in order to harmonize national energy goals with goals and time framework of strategic documents of the European Union. The adoption of the energy strategy implementation program with associated measures is still in process. The goal of the strategy was to create sustainable energy system that will make a balanced contribution to the security of energy supply, competitiveness and environmental protection in Croatia. In this paper an overview of the energy production, final energy consumption and planned development of energy infrastructure is given. The intention of the paper was to research and stress out the abilities and opportunities of Croatian energy system and to give recommendations for energy strategy implementation and practical realization of planned energy infrastructure projects for improvement of security of energy supply and competitiveness of energy system of the Republic of Croatia.

12/01661 The pricing of charging for electric vehicles in China – dilemma and solution

Li, Z. and Ouyang, M. *Energy*, 2011, 36, (9), 5765–5778.

The number of electric vehicles in China is expected to grow rapidly, triggering the national large-scale construction of charging stations. At the same time, a reasonable charging price has not been established. This article records the views of station operators and electric vehicle users and calculates a charging pricing range. The price should not only ensure the profit of operators, but also help reduce electric vehicle users' expenditure compared to using internal-combustion-engine vehicles. Based on current energy prices and battery costs, charging stations are unable to make profit, and the pricing shortfall is up to 0.78 RMB yuan $(\mathrm{kWh})^{-1}$. Only with a 25% increase in energy price or 25% reduction in battery cost can charging stations become profitable. Several suggestions are proposed to improve station profits. First, ensuring a high station load is helpful to increase profits, and it is estimated the reasonable number of chargers in Beijing is approximately 6000, distributed among 672 stations. Second, the use of storage batteries for on/off-peak electricity self-management can also increase the annual profit by 600,000 RMB yuan. In addition, other methods like a joined station alliance, multiple energy supplement approaches, vehicle-to-grid technology and state subsidy can also accelerate the development of the charging service industry.

12/01662 Volatility spillovers between food and energy markets: a semiparametric approach

Serra, T. *Energy Economics*, 2011, 33, (6), 1155–1164.

Previous literature on volatility links between food and energy prices is scarce and mainly based on parametric approaches. This article examines these links by using a semiparametric GARCH model, which is essentially a non-parametric correction of the parametric conditional covariance function. The analysis focuses on price links between crude oil, ethanol and sugar prices in Brazil. Results suggest strong volatility links between the prices studied. Parametric approximations of the conditional covariance matrix may lead to misleading results that can be improved on by using non-parametric techniques.

Energy conservation

12/01663 A simple dynamic energy capacity model

Gander, J. P. *Energy Economics*, 2012, 34, (1), 78–81.

A simple dynamic model is developed showing how total energy capacity is allocated to two different uses and how these uses and their corresponding energy flows are related and behave through time. The control variable of the model determines the allocation. All the variables of the model are in terms of a composite energy equivalent measured in BTUs. A focus is on the shadow price of energy capacity and its behaviour through time. Another focus is on the behaviour of the control variable that determines the allocation of overall energy capacity. The matching or linking of the model's variables to real world US energy data is undertaken. In spite of some limitations of the data, the model and its behaviour fit the data fairly well. Some energy policy implications are discussed.

12/01664 Advances in household appliances – a review

Bansal, P. *et al. Applied Thermal Engineering*, 2011, 31, (17–18), 3748–3760.

An overview of options and potential barriers and risks for reducing the energy consumption, peak demand, and emissions for seven key energy consuming residential products (refrigerator-freezers, dishwashers, clothes washers, clothes dryers, electric ovens, gas ovens and microwave ovens) is presented. The paper primarily concentrates on the potential energy savings from the use of advanced technologies in appliances for the US market. The significance and usefulness of each technology was evaluated in order to prioritize the R&D needs to improve energy efficiency of appliances in view of energy savings, cost, and complexity. The paper provides a snapshot of the future R&D needs for each of the technologies along with the associated barriers. Although significant energy savings may be achieved, one of the major barriers in most cases is high first cost. One way of addressing this issue and promoting the introduction of new technologies is to 'level' the playing field for all manufacturers by establishing minimum energy performance standards which are not cost prohibitive and promoting energy efficient products through incentives to both manufacturers and consumers.

12/01665 Building energy-efficiency standards in a life cycle primary energy perspective

Dodoo, A. *et al. Energy and Buildings*, 2011, 43, (7), 1589–1597.

In this study the life cycle primary energy use of a wood-frame apartment building designed to meet the current Swedish building code, the Swedish building code of 1994 or the passive house standard, and heated with district heat or electric resistance heating is analysed. The analysis includes the primary energy use during the production, operation and end-of-life phases. It is found that an electrically heated building built to the current building code has greater life cycle primary energy use relative to a district-heated building, although the standard for electric heating is more stringent. Also, the primary energy use for an electrically heated building constructed to meet the passive house standard is substantially higher than for a district-heated building built to the Swedish building code of 1994. The primary energy for material production constitutes 5% of the primary energy for production and space heating and ventilation of an electrically heated building built to meet the 1994 code. The share of production energy increases as the energy-efficiency standard of the building improves and when efficient energy supply is used, and reaches 30% for a district heated passive house. This study shows the significance of a life cycle primary energy perspective and the choice of heating system in reducing energy use in the built environment.

12/01666 Comparative evaluation of performance and energy consumption of hot air and superheated steam impinging stream dryers for high-moisture particulate materials

Choicharoen, K. *et al. Applied Thermal Engineering*, 2011, 31, (16), 3444–3452.

Impinging stream dryer (ISD) is a novel alternative to flash dryer for drying high-moisture particulate materials. A number of studies have been conducted on various aspects of an ISD; however, in almost all of the previous studies hot air was used as the drying medium. Since it is well recognized that use of superheated steam as the drying medium could lead to much reduced net energy consumption of the drying process, it was the aim of the present study to investigate the use of superheated steam as the drying medium in an ISD. Okara (soy residue) was used as a test high-moisture particulate material. The performance of the drying system, in terms of the volumetric heat transfer coefficient and volumetric water evaporation rate, as affected by the superheated steam temperature, steam velocity, material feed flow rate and the dryer geometric parameter viz. impinging distance was assessed. In addition, the ability to reuse the exhausted steam as well as the specific energy consumption of the system were evaluated. Comparison was made with the hot air drying results. The maximum volumetric water evaporation rate was found to be around 807 $\mathrm{kg_{water}/m^3h}$, while the maximum volumetric heat transfer coefficient was around 7950 $\mathrm{W/m^3K}$ at the steam recycle ratios of 46–63%. The lowest total specific energy consumption of the system was around 3.1 $\mathrm{MJ/kg_{water}}$ at an inlet steam temperature of 190 °C, inlet steam velocity of 20 m/s, material feed flow rate of 20 $\mathrm{kg_{dry\ solid}/h}$, impinging distance of 5 cm and steam recycle ratio of 63%. Compared with the hot air drying results at the same corresponding conditions, savings of the total specific energy consumption in the range of 9–46% were noted.

12/01667 Constructing post-carbon institutions: assessing EU carbon reduction efforts through an institutional risk governance approach

LaBelle, M. *Energy Policy*, 2012, 40, 390–403.

This paper examines three different governance approaches the European Union (EU) and member states (MS) are relying on to reach a low carbon economy by 2050. Current governance literature explains the operational methods of the EU's new governance approach to reduce carbon emissions. However, the literature neglects to account for the perceived risks that inhibit the roll-out of new low carbon technology. This article, through a novel approach, uses a grounded theoretical framework to reframe traditional risk literature and provides a connection to governance literature in order to assess the ability of EU governance mechanisms to reduce carbon emissions. The empirical research is based on responses from European energy stakeholders who participated in a Delphi method discussion and in semi-structured interviews; these identified three essential requirements for carbon emissions to be reduced to near zero by 2050: (1) an integrated European energy network, (2) carbon pricing and (3) demand reduction. These features correspond to institutionalized responses by the EU and MS: the Agency for the Cooperation of Energy Regulators (ACER); European Union Emission Trading Scheme (EU ETS) and energy efficiency directives and policies integrated into existing MS institutions. The theoretical and empirical findings suggest that governance by facilitation (energy efficiency) fails to induce significant investment and new policy approaches and cannot be relied on to achieve requisite reductions in demand. Governance by negotiation (ACER) and governance by hierarchy (EU ETS) do reduce risks and may encourage the necessary technological uptake. The term 'risk governance' is used to explain the important role governance plays in reducing risks and advancing new technology and thereby lowering carbon emissions in the energy sector.

12/01668 Decoupling dehumidification and cooling for energy saving and desirable space air conditions in hot and humid Hong Kong

Lee, W. L. *et al. Energy Conversion and Management*, 2012, 53, (1), 230–239.

The combined use of dedicated outdoor air ventilation (DV) and dry cooling (DC) air-conditioning system to decouple sensible and latent cooling for desirable space air conditions, better indoor air quality, and energy efficiency is proposed for hot and humid climates like Hong Kong. In this study, the performance and energy saving potential of DCDV system in comparison to conventional systems (constant air volume (CAV) system with and without reheat) for air conditioning of a typical office building in Hong Kong are evaluated. Through hour-by-hour simulations, using actual equipment performance data and realistic building and system characteristics, the cooling load profile, resultant indoor air conditions, condensation at the DC coil, and energy consumptions are calculated and analysed. The results indicate that with the use of DCDV system, the desirable indoor conditions could be achieved and the annual energy use could be reduced by 54% over CAV system with reheat. The condensate-free characteristic at the DC coil to reduce risk of catching disease could also be realized.

12/01669 Economic and geopolitical dimensions of renewable vs. nuclear energy in north Africa

Marktanner, M. and Salman, L. *Energy Policy*, 2011, 39, (8), 4479–4489.

Addressing issues of renewable energy in north Africa must incorporate concerns regarding the compatibility of energy mixes with the nature of political regimes, their geopolitical relevance, and their socio-economic effects, in addition to economic cost-benefit deliberations. One important and under-researched aspect of nuclear energy refers to the trade-off between socio-economic development and political power conservation. Competing interests in north Africa's energy market as well as aspects of regional co-operation capacity are important when assessing the choice between renewable and nuclear energy. Therefore, the future course of meeting north Africa's energy needs is subject to a complex political and economic interplay between domestic and geopolitical development interests. The objective of this paper is to explore this complexity in more detail. The authors argue that the identification of any energy alternative as superior is hardly convincing unless certain standards of inclusive governance are met. It is also found that it is important to highlight political–economic differences between energy importers like Morocco and Tunisia and energy exporters like Algeria, Libya, and Egypt.

12/01670 Energy and cost savings in household refrigerating appliances: a simulation-based design approach

Negrão, C. O. R. and Hermes, C. J. L. *Applied Energy*, 2011, 88, (9), 3051–3060.

In this study a novel design methodology for household refrigeration systems focused on both energy savings and cost reduction is presented and evaluated. Mathematical models were put forward for each of the system components and used to simulate the energy performance of the entire refrigeration system. The system simulation model was validated against experimental data obtained for a single-door 300-litre vertical freezer. It was found that the model predictions for the energy consumption, cooling capacity and runtime ratio deviated from the experimental data within an error band of ±10%. An optimization algorithm was built upon the simulation model to size the condenser and evaporator heat transfer areas, and also the cabinet insulation thickness aiming at minimizing the total cost of the refrigeration system for a target energy consumption. A trade-off relation between the minimum cost and the minimum energy consumption was achieved, bringing about a system configuration that consumes 14% less energy than the baseline system if the total cost remains unchanged. The effect of the compressor stroke volume and efficiency on the minimum cost was also taken into account. It was demonstrated that the refrigerator/freezer becomes less costly in cases where highly efficient compressors are used in low energy consumption refrigerating appliances.

12/01671 Energy efficiency actions related to the rollout of smart meters for small consumers, application to the Austrian system

Olmos, L. *et al. Energy*, 2011, 36, (7), 4396–4409.

Smart meters (SM) may provide large benefits to all stakeholders by providing the information required to implement certain sets of demand response actions. Benefits produced by SM related actions depend on the features of these actions, the system and the targeted consumer group. The authors first lay out an analytical framework to analyse the application of demand response (DR) actions. Based on this framework, a way to determine the response of domestic load in a system to the implementation of DR actions is described. The authors propose determining the overall change in the consumption behaviour of domestic load based on previously obtained estimates of the peak load and overall consumption reduction for different types of consumers in different types of systems resulting from the application of each set of actions. A comprehensive literature review was carried out to provide such estimates. The analytical framework and methodology developed are applied to characterize the reaction of consumers in the Austrian system to different SM-related actions. Finally, guidelines on which DR actions to implement in this system and how to implement them are provided. The use of advanced indirect feedback on consumption behaviour, critical peak prices and simple time-of-use tariffs is advocated.

12/01672 Energy saving potential and repercussions on indoor air quality of demand controlled residential ventilation strategies

Laverge, J. *et al. Building and Environment*, 2011, 46, (7), 1497–1503.

Ventilation is ambiguously related to the energy saving rationale originating from the mitigation of global warming, the reaching of peak oil or health concerns related to fossil fuel burning. Since it makes up for about half of the energy consumption in well-insulated buildings, it is an attractive target for energy saving measures. However, simply reducing ventilation rates has unwanted repercussions on the indoor air quality. Two main strategies have been developed to reconcile these seemingly opposing interests: heat recovery and demand control ventilation. This paper focuses on the energy saving potential of demand controlled mechanical exhaust ventilation in residences and on the influence such systems may have on the indoor air quality to which the occupants of the dwellings are exposed. The conclusions are based on simulations done with a multi-zone airflow model of a detached house that is statistically representative for the average Belgian dwelling. Four approaches to demand based control are tested and reported. Within the paper exposure to carbon dioxide and to a tracer gas are used as indicators for indoor air quality. Both energy demand and exposures are reported and compared to the results for a standard, building code compliant, exhaust system, operating at continuous flow rates. The sensitivity of the control strategies to environmental and user variations is tested using Monte-Carlo techniques. Under the conditions that were applied, reductions on the ventilation heat loss of 25–60% are found, depending on the chosen control strategy (with the exclusion of adventitious ventilation and infiltration).

12/01673 Environmental and economic performance of heating systems for energy-efficient dwellings: case of passive and low-energy single-family houses

Georges, L. *et al. Energy Policy*, 2012, 40, 452–464.

In order to reduce the energy consumption of the building stock, a major trend is to drastically reduce the space heating (SH) needs by improving the thermal performance of the envelope. In general, this measure is combined with efficient heating systems to minimize the delivered energy and greenhouse gas emissions. Nevertheless, these better systems are often more expensive so that the extra-investment could be hardly recovered for small-scale energy consumption. The main objective of the article is to show how equilibria between cost-effectiveness and environmental performance of heating systems are changed when small SH needs are considered (i.e. for passive and low-energy houses). The scope is limited to new single-family dwellings. Furthermore, the passive house standard provides means of simplifying the SH by using the ventilation air: the idea is that savings should counterbalance the extra-investment in super-insulation. In theory, a new global economic optimum is generated at the passive house level. The second objective of the work is to study which conditions could lead to this new optimum. Only a detached-house typology is investigated to address this last issue. Regarding methodology, all the investigations are done considering the Belgian context. Energy and environmental performance is evaluated using a method that complies with the EN-15603 and EN-15316 standards.

12/01674 Environmental impact of building-related and user-related energy consumption in dwellings

Blom, I. *et al. Building and Environment*, 2011, 46, (8), 1657–1669.

Energy consumption in dwellings contributes significantly to their total negative environmental impact. This paper quantitatively assesses the environmental impact of building-related and user-related gas and electricity consumption in a Dutch apartment dwelling using life cycle assessment methodology. Several scenarios for gas and electricity consumption are compared to assess what effect changes in building characteristics and user behaviour have on the environmental impacts of energy consumption. This study shows that gas consumption significantly contributes to four environmental impact categories, which can be most effectively countered by reducing the heat demand of the dwelling. A 23% reduction in gas consumption leads to up to 13% less overall environmental impacts. Particularly in buildings with low heat demand, electricity consumption dominates all environmental impact categories. These can most effectively be reduced by changing the electricity demand of the user: 47% less electricity consumption leads to a 9–45% reduction in the total environmental impact. However, since electricity consumption continues to rise, the environmental effects of electricity use may be better reduced by changing the environmental impact of the electricity supply. Theoretically, when electricity consumption remains the same, over 90% less environmental impact could be reached by using 100% wind power to generate electricity.

12/01675 Evaporative cooling as an efficient system in Mediterranean region

Jaber, S. and Ajib , S. *Applied Thermal Engineering*, 2011, 31, (14–15), 2590–2596.

In this work, indirect evaporative air-conditioning was thermally designed in order to reduce energy consumption without negatively affecting the thermal comfort and in order to lower the imported oil bill on the national level and reducing the emission of harmful gasses to the environment on the international level. Moreover, the economic impact of such system was studied. The outcomes show that indirect evaporative air-conditioning can be covered most of the total annual load at $1100\,\mathrm{l\,s^{-1}}$. Furthermore, once indirect evaporative air-conditioning in 500,000 Mediterranean residential buildings are used instead of traditional one, the annual estimated energy saving is about 1084 GWh/a and the annual total avoided CO_2 emission is estimated to be 637,873 Ton. The payback period for such system from the saving that occurred is less than 2 years.

12/01676 Feasibility of thermal energy storage systems in an institutional building in subtropical climates in Australia

Rahman, M. M. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2943–2950.

Thermal energy storage (TES) is a preferred demand-side management (DSM) technology for shifting cooling load demand from peak hour to off-peak hour in the heating, ventilating and air conditioning (HVAC) industry. In this study, the technical and economic feasibility of introducing TES systems in a building in subtropical Central Queensland, Australia is presented. First, the cooling load profile of existing systems is simulated using building simulation software DesignBuilder and verified with on-site measured data. Then, using the verified simulation technique, the technical and economic feasibility of TES systems are analysed for both full and partial storage scenarios. The results show that the full and partial chilled storage systems can save up to 61.19% and 50.26% respectively of the electricity cost required for cooling when compared with the conventional system in subtropical climate.

12/01677 GDP and environment pressure: the role of energy in Latin America and the Caribbean

Zilio, M. and Recalde, M. *Energy Policy*, 2011, 39, (12), 7941–7949.

This paper analyses the relationship between economic growth and energy consumption for a sample of 21 Latin American and Caribbean countries during the 1970–2007 period. The investigation is made on the bases of the energy environmental Kuznets curve hypothesis, using a panel data analysis. Energy consumption at aggregate level is used as an indicator of human environmental pressure and gross domestic product per capita as an indicator of economic activity. Based in a cointegration approach, the results do not support the existence of a stable long-run relationship between the series, rejecting the validity of such hypothesis for the selected sample over the 1970–2007 period.

12/01678 Influence of the number of users on the energy efficiency of health centres

Sanz-Calcedo, J. C. *et al. Energy and Buildings*, 2011, 43, (7), 1544–1548.

The present work is aimed at evaluating the influence of various factors – mainly number of users – on both energy and environmental features of a health centre by quantifying their incidence on the sizing of the building, as well as on energy consumption and its management. A total of 70 health centres located in eight health areas of Extremadura (a south-western region of Spain) were analysed from both energy and environmental perspectives. In particular, the most influential parameters on buildings' daily management were studied. Also, a sensitivity analysis to establish empirical connections between energy indicators and the operating parameters was carried out. Finally, geographic information systems were used to explore possible correlations with other factors related to buildings' location.

12/01679 Intelligent energy management control of vehicle air conditioning via look-ahead system

Khayyam, H. *et al. Applied Thermal Engineering*, 2011, 31, (16), 3147–3160.

Air conditioning systems (AC) significantly increase the energy consumption of a vehicle and negatively influence its performance. AC can be considered the main auxiliary load on a vehicle engine when it is operating. Thus, there are significant savings to be made by operating an AC system smartly, both in terms of running costs and the effect on the environment. This paper presents an intelligent energy management system that is able to reduce the energy consumption of a vehicle with an AC system and improve its efficiency by using the look-ahead system uses information from various information systems to make intelligent decisions. The new energy management system features: a prediction of road power demand by using look-ahead control of vehicle systems, an intelligent control strategy to manage the operation of the AC, the blower, and the gates, to provide the optimum comfort temperature with the consideration of the in cabin air quality while minimizing energy consumption. Two simulations are performed by using the developed fuzzy AC enhanced look-ahead system and ordinary fuzzy air conditioning and then the results are compared together with the results from co-ordinated energy management system (CEMS). The results of fuzzy air conditioning enhanced with look-ahead system demonstrate it is capable of saving 12% and 3% more energy comparing with CEMS and ordinary fuzzy air conditioning system respectively.

12/01680 Model-based optimal control of a dedicated outdoor air-chilled ceiling system using liquid desiccant and membrane-based total heat recovery

Ge, G. *et al. Applied Energy*, 2011, 88, (11), 4180–4190.

This study presents a model-based control strategy for a novel dedicated outdoor air-chilled ceiling (DOAS-CC) system with the aim of optimizing the overall system performance. The DOAS-CC system incorporates liquid desiccant dehumidification and membrane-based total heat recovery technologies. Simplified but reliable models of major components in the DOAS-CC system are firstly developed to predict the system performance. A cost function is then constructed to minimize total energy consumption while properly maintaining thermal comfort reflected by indoor air temperature and relative humidity. Genetic algorithm is used to search for optimal set-points of the supply air temperature and humidity ratio of the dedicated outdoor air subsystem as well as the supply water temperature. The performance of this strategy is tested and evaluated with different control settings in a simulated multi-zone space served by the DOAS-CC system under various weather conditions. The results show that optimized control variables produced by the optimal strategy can improve the system energy performance and maintain indoor thermal comfort.

12/01681 Modeling and explaining the dynamics of European Union allowance prices at high-frequency

Conrad, C. *et al. Energy Economics*, 2012, 34, (1), 316–326.

In this paper the authors model the adjustment process of European Union allowance (EUA) prices to the releases of announcements at high-frequency controlling for intraday periodicity, volatility clustering and volatility persistence. The authors find that the high-frequency EUA price dynamics are very well captured by a fractionally integrated asymmetric power GARCH process. The decisions of the European Commission on second national allocation plans have a strong and immediate impact on EUA prices. Further, EUA prices increase in response to better than expected news on the future economic development as well as the current economic activity in Germany and the USA.

12/01682 Optimisation of a Swedish district heating system with reduced heat demand due to energy efficiency measures in residential buildings

Åberg, M. and Henning, D. *Energy Policy*, 2011, 39, (12), 7839–7852.

The development towards more energy efficient buildings, as well as the expansion of district heating (DH) networks, is generally considered to reduce environmental impact. But the combined effect of these two progressions is more controversial. A reduced heat demand (HD) due to higher energy efficiency in buildings might hamper co-production of electricity and DH. In Sweden, co-produced electricity is normally considered to displace electricity from less efficient European condensing power plants. In this study, a potential HD reduction due to energy efficiency measures in the existing building stock in the Swedish city Linköping is calculated. The impact of HD reduction on heat and electricity production in the Linköping DH system is investigated by using the energy system optimisation model MODEST. Energy efficiency measures in buildings reduce seasonal HD variations. Model results show that HD reductions primarily decrease heat-only production. The electricity-to-heat output ratio for the system is increased for HD reductions up to 30%. Local and global CO_2 emissions are reduced. If co-produced electricity replaces electricity from coal-fired condensing power plants, a 20% HD reduction is optimal for decreasing global CO_2 emissions in the analysed DH system.

12/01683 Overview of thermal energy storage (TES) potential energy savings and climate change mitigation in Spain and Europe

Arce, P. *et al. Applied Energy*, 2011, 88, (8), 2764–2774.

Thermal energy storage (TES) is nowadays presented as one of the most feasible solutions in achieving energy savings and environmentally correct behaviours. Its potential applications have led to R&D activities and to the development of various technology types. However, so far there is no available data on a national scale in Spain and on a continental level in Europe, to corroborate the associated energetic and environmental benefits derived from TES. This is why, based on a previous potential calculation initiative model performed in Germany, this work intends to provide a first overview of the Spanish TES potential as well as an European overview. Load reductions, energy savings, and CO_2 emissions reductions are tackled for the buildings and industrial sector. Results depend on the amount of implementation and show that, in the case of Europe for instance, yearly CO_2 emissions may get to be cut down up to around 6% in reference to 1990 emission levels.

12/01684 Tank size and operating strategy optimization of a stratified chilled water storage system

Zhang, Z. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2656–2664.

In the downtown area of Austin, Texas, USA, it is planned to build a new naturally stratified chilled water storage tank and share it among four separated chilled water plants in order to reduce the utility billing cost. Each plant is charged with a typical time-of-use utility rate including energy charge and demand charge. This paper presents the method of determining the optimal tank size as well as corresponding optimal operating strategies for this project. A simplified thermal energy storage plus four plants model is built based on some assumptions. Three conventional control strategies (full storage, chiller priority, and storage priority) with limitations on the maximum number of chillers running during the off-peak and on-peak periods are simulated. The results show that a tanks of 3.5 million gallons (13,249 m^3) has the shortest simple payback time and the projected total capital cost is within the budget. Full storage strategy is selected for the summer months and storage-priority strategy is selected for the winter months. The annual billing cost savings are estimated at $907,231 and the simple payback time is 12.5 years.

12/01685 The emergence and evolution of regional convergence clusters in China's energy markets

Ma, H. and Oxley, L. *Energy Economics*, 2012, 34, (1), 82–94.

Employing the new regression tests for convergence, club convergence and clustering proposed earlier elsewhere, this paper models and analyses the behaviour of China's energy sectors. Energy market 'convergence clusters' are identified using new price data, and their regional spatial distributions are mapped for four major fuel types: coal, gasoline, diesel and electricity. The findings are as follows. (i) As yet, there are no fully integrated national energy markets in China, as more than one convergence cluster is identified for all four fuels. (ii) Some regional energy markets can be regarded as 'quite mature,' as evidenced by the existence of some highly concentrated convergence clusters connected geographically. (iii) Some regional markets remain in a 'state of transition,' as witnessed by convergence clusters that are scattered geographically and that are growing in membership. (iv) It seems that there is more regional-based integration for coal and electricity than for gasoline and diesel, as more convergent clusters were identified for coal and electricity than for gasoline and diesel (v) Overall, China still appears to be in the process of energy market integration, as demonstrated by the number and evolution of convergence clusters over time.

12/01686 The potential and need for energy saving in standard family detached and semi-detached wooden houses in arctic Greenland

Bjarløv, S. P. and Vladykova, P. *Building and Environment*, 2011, 46, (8), 1525–1536.

The paper gives an account of the potential and need for energy saving in standard family detached and semi-detached wooden houses in Greenland. It is based on studies of house construction compared with Building Regulation requirements and the spread of buildings over time. In the climatic conditions of Greenland, there is considerable potential for energy saving in houses due to their construction, shape and condition. To estimate the total potential for energy saving and thus reducing CO_2 emissions, a detailed investigation of three typical standard semi-detached family houses (type 18D) was carried out. Temperature, relative humidity and air tightness were measured, and thermal bridges were determined from drawings, visual inspection, and by using a thermal camera. The findings show a current energy consumption of up to 383 kWh/(m^2 a) for heating, poor air tightness, a large number of thermal bridges, and high indoor temperatures. A potential for a reduction in CO_2 emission by a factor of 10 was demonstrated. Finally, the paper describes a practical way of reducing thermal bridges significantly, increasing air tightness, upgrading insulation and adding mechanical ventilation to approximately half of the housing stock without changing the architectural expression or having to relocate the occupants during the renovation.

12/01687 Thermal performance analysis according to wood flooring structure for energy conservation in radiant floor heating systems

Seo, J. *et al. Energy and Buildings*, 2011, 43, (8), 2039–2042.

The aim of this study was to reduce energy consumption, especially heating, in buildings. Improvements in the thermal conductivity of wood flooring, which was considered to decrease heating between floors and the indoor areas, were investigated. Wood flooring components such as solid-wood, high-density fibreboard (HDF), adhesives and polyethylene generally exhibit low thermal conductivity. The thermal conductivity and transfer performance of 21 replicates of wood flooring materials generally used in Korea were measured. The thermal conductivity was measured by using the guarded hot plate method. The thermal conductivities differed according to the structure of the floorings. Laminate wood flooring exhibited the highest thermal conductivity because of its high density and thin layers compared to the other floorings. The thermal transfer performance differed according to the installation method. The floating installation method exhibited a lower thermal transfer speed than the adhesion installation method because of its air layers and polyethylene form.

12/01688 Two energy conservation principles in convective heat transfer optimization

Yuan, F. and Chen, Q. *Energy*, 2011, 36, (9), 5476–5485.

Improving heat transfer performance is very beneficial to energy conservation because heat transfer processes widely existed in energy utilization systems. In this contribution, in order to effectively optimize convective heat transfer, such two principles as the field synergy principle and the entransy dissipation extremum principle are investigated to reveal the physical nature of the entransy dissipation and its intrinsic relationship with the field synergy degree. The authors first established the variational relations of the entransy dissipation and the field synergy degree with the heat transfer performance, and then derived the optimization equation of the field synergy principle and made comparison with that of the entransy dissipation extremum principle. Finally the theoretical analysis is then validated by the optimization results in both a fin-and-flat tube heat exchanger and a foursquare cavity. The results show that, for prescribed temperature boundary conditions, the above two optimization principles both aim at maximizing the total heat flow rate and their optimization equations can effectively obtain the best flow pattern. However, for given heat flux boundary conditions, only the optimization equation based on the entransy dissipation extremum principle intends to minimize the heat transfer temperature difference and could get the optimal velocity and temperature fields.

12/01689 Will history repeat itself? Economic convergence and convergence in energy use patterns

Jakob, M. *et al. Energy Economics*, 2012, 34, (1), 95–104.

In this paper, a difference-in-differences estimator on panel data for 30 developing and 21 industrialized countries is employed over the period 1971–2005 to examine how patterns of energy use (characterized by the consumption of primary energy carriers, sectoral energy use and carbon emissions) are changing in the process of economic development. For the average developing country in the sample, the results indicate that economic catch-up has been accompanied by above-average growth of the use of most primary energy carriers, the consumption of final energy in most sectors and total CO_2 emissions. For industrialized countries, it is found that economic growth is partially decoupled from energy consumption and that above average rates of economic growth were accompanied by larger improvements in energy efficiency. These results emphasize the need to identify the relevant engines of economic growth, their implications for energy use and possibilities to achieve low-carbon growth centred on productivity and efficiency improvements rather than on capital accumulation.

17 ENERGY CONVERSION AND RECYCLING

12/01690 An analysis of used lubricant recycling, energy utilization and its environmental benefit in Taiwan

Tsai, W.-T. *Energy*, 2011, 36, (7), 4333–4339.

Utilizing used lubricants as energy sources has been currently demonstrated to be one of the best available waste management methods. In this regard, used lubricants for use as energy sources in Taiwan thus became popular in recent years. The objective of this study was to present a comprehensive analysis of used lubricant-to-energy in Taiwan, which includes status of lubricant consumption, and used lubricant generation and its recycling (i.e. collection and treatment) management system. It was found that a major market for utilizing used lubricants in Taiwan (over 90%) was reused as fuel oils or auxiliary fuels in the cogeneration system. Under the regulatory authorization of the Waste Management Act and the Petroleum Administration Act, the central competent authorities encouraged the energy-intensive industries in the waste-to-energy through the excess electricity purchase and subsidiary incentives. Based on the certified volume of collected used lubricant and its energy use proportion in 2009, the total energy potential and the environmental benefit of mitigating CO_2 emissions in place of fuel oils were preliminarily calculated to be around 9.4×10^2 TJ and 7.3×10^7 kg, respectively.

12/01691 An experimental study on the performance of enthalpy recovery system for building applications

Mardiana-Idayu, A. and Riffat, S. B. *Energy and Buildings*, 2011, 43, (9), 2533–2538.

In recent years, the attention of researchers has been focused on energy conservation demands due to the environmental impact of energy consumption throughout the built environment and global warming issue. Heat or energy recovery is one of the main energy-efficient systems that has been approved to overcome this problem. However, in conventional heat or energy recovery for building applications, only sensible energy has been recovered and neglecting the latent energy. In this work, enthalpy recovery system has been developed and the performances of sensible and latent energy have been investigated experimentally. The efficiency of close to 66% has been achieved for sensible energy and the latent energy efficiency was nearly 59% gained. Comparison of efficiency with effectiveness-NTU method showed both were in good agreement. Recovered energy was achieved up to 167 W at 3.0 m/s air velocity with 4.3 °C temperature difference.

12/01692 Energy efficiency improvement of a Kraft process through practical stack gases heat recovery

Goortani, B. M. *et al. Applied Thermal Engineering*, 2011, 31, (17–18), 4091–4096.

A process scheme for the optimal recovery of heat from stack gases considering energy and technical constraints has been developed and applied to an existing Kraft pulping mill. A system based on a closed loop recirculation of hot oil is used to recover the heat from stack gases and distribute it to the appropriate cold streams. The recovery of heat from stack gases is part of an overall optimization of the Kraft mill. Tools such as pinch analysis and exergy analysis are used to evaluate the process streams. The results indicate that 10.8 MW of heat from stack gases can be reused to heat process streams such as the deaerator water, hot water, drying filtrates, and black liquor. A simulation model of the recirculation loop has been developed to determine the specifications of the recovery system. The total heat exchanger surface area required by the system is $3460\,m^2$, with a hot oil recirculation temperature of 137 °C. The anticipated total investment is $10.3 M, with a payback time of 1.8 years.

12/01693 Energy production from landfill biogas: an Italian case

Caresana, F. *et al. Biomass and Bioenergy*, 2011, 35, (10), 4331–4339.

The study considers the ‘renovation’ (as defined by Italian legislation) of an electricity-generating plant using biogas produced in a managed landfill as the primary energy source. The landfill, located in the Marche region (central Italy), receives about $100\,kt\,y^{-1}$ of urban and industrial residues. The plant is endowed with two 470 kW(e) internal combustion engines and has been in operation since 1998. At the end of its lifecycle it is scheduled for decommissioning. Public incentives for energy production from renewable sources, which the plant enjoyed in the first eight years of activity, have also expired. The study examines the main legal, technical and economic options available to the landfill management, in particular considering the new Italian and European Union incentives for energy generation from renewable sources. Five configurations are considered for the replacement of the existing engines, three at the original site (a single combustion engine with/without incentives, and a plant with microturbines), and two involving the construction of new plants at a separate site (a cogeneration plant with a combustion engine and one with microturbines). The study provides data that may be a useful basis for other similar cases and for simulations.

12/01694 Energy recovery from high temperature slags

Barati, M. *et al. Energy*, 2011, 36, (9), 5440–5449.

Molten slags represent one of the largest untapped energy sources in metal manufacturing operations. The waste heat of slags amounting to ~220 TWh/year at temperatures in the range of 1200–1600 °C, presents an opportunity to lower the energy intensity of metal production. Currently, three types of technologies are under development for utilizing the thermal energy of slags; recovery as hot air or steam, conversion to chemical energy as fuel, and thermoelectric power generation. The former route is most developed with its large scale trials demonstrating recovery efficiencies up to 65%. The latter two are emerging as the next generation methods of waste heat recovery. An evaluation of these methods shows that for both thermal and chemical energy recovery routes, a two-step process would yield a high efficiency with minimal technical risk. For thermoelectric power generation, the use of phase change materials appears to solve some of the current challenges including the mismatch between the slag temperature and operating range of thermoelectric materials.

12/01695 Evaluation of bioenergy recovery processes treating organic residues from ethanol fermentation process

Juang, C.-P. *et al. Bioresource Technology*, 2011, 102, (9), 5394–5399.

This study evaluates a two-stage bioprocess for recovering bioenergy in the forms of hydrogen and methane while treating organic residues of ethanol fermentation from tapioca starch. A maximum hydrogen production rate of $0.77\,mmol\,H_2/g\,VSS/h$ can be achieved at volumetric loading rate (VLR) of $56\,kg\,COD/m^3/day$. Batch results indicate that controlling conditions at $S_0/X_0 = 12$ with $X_0 = 4000\,mg\,VSS/L$ and pH 5.5–6 are important for efficient hydrogen production from fermentation residues. Hydrogen-producing bacteria enriched in the hydrogen bioreactor are likely utilizing lactate and acetate for biohydrogen production from ethanol-fermentation residues. Organic residues remained in the effluent of hydrogen bioreactor can be effectively converted to methane with a rate of $0.37\,mmol\,CH_4/g\,VSS/h$ at VLR of $8\,kg\,COD/m^3/day$. Approximately 90% of COD in ethanol-fermentation residues can be removed and among that 2% and 85.1% of COD can be recovered in the forms of hydrogen and methane, respectively.

12/01696 Experimental research on condensing heat recovery using phase change material

Zhang, X. *et al. Applied Thermal Engineering*, 2011, 31, (17–18), 3736–3740.

Utilization of air conditioning condensing heat recovery in daily hot water preparation was propitious to energy conservation. A condensing heat recovery with thermal storage of phase change material (paraffin wax as PCM) has been designed and analysed in this paper. Related studies such as charging and discharging experiment, comparison between air conditioning with or without the thermal storage container, relationship between temperature rise and flow rate were also researched. It could be concluded that sensible condensing heat could be recovered effectively by a thermal storage container added and air conditioning system kept in order with condensing heat recovery. Experiments showed larger flow rate leaded to less temperature rise of cold water during the discharging process.

12/01697 Numerical study of a metal hydride heat transformer for low-grade heat recovery: simulation of a *M*H heat transformer

Yang, F. S. *et al. Applied Thermal Engineering*, 2011, 31, (14–15), 2749–2756.

Due to the increasing demand for clean energy and improved energy utilization, the metal hydride heat transformer for low-grade heat recovery has attracted wide attentions recently. In this paper, such a system with $LaNi_5$–$LaNi_{4.7}Al_{0.3}$ pair, which is used for upgrading waste heat to a higher temperature, was investigated in detail by numerical simulation. Different from existing studies, in this investigation only ambient and waste heat sources are involved during operation of the heat transformer, which could be advantageous in many aspects. A rigorous 2-D unsteady model was developed and numerically solved by the fully implicit finite volume method (FVM). It was shown that the proposed system can achieve steady heat upgrading operation, resulting in an average temperature boost of 6.8 K using a 358 K waste heat source. The dynamic behaviour of the heat transformer in three subsequent cycles was analysed, and the measures aiming at continuous output were further discussed.

12/01698 Optimal waste heat recovery and reuse in industrial zones

Stijepovic, M. Z. and Linke, P. *Energy*, 2011, 36, (7), 4019–4031.

Significant energy efficiency gains in zones with concentrated activity from energy intensive industries can often be achieved by recovering and reusing waste heat between processing plants. A systematic approach to target waste heat recovery potentials and design optimal reuse options across plants in industrial zones is presented. The approach first establishes available waste heat qualities and reuse feasibilities considering distances between individual plants. A targeting optimization problem is solved to establish the maximum possible waste heat recovery for the industrial zone. Then, a design optimization problem is solved to identify concrete waste heat recovery options considering economic objectives. The paper describes the approach and illustrates its application with a case study.

12/01699 Primary energy implications of ventilation heat recovery in residential buildings

Dodoo, A. *et al. Energy and Buildings*, 2011, 43, (7), 1566–1572.

In this study, the impact of ventilation heat recovery (VHR) on the operation primary energy use in residential buildings is analysed. The operation primary energy use is calculated of a case-study apartment building built to conventional and passive house standard, both with and without VHR, and using different end-use heating systems including electric resistance heating, bedrock heat pump and district heating based on combined heat and power (CHP) production. VHR increases the electrical energy used for ventilation and reduces the heat energy used for space heating. Significantly greater primary energy savings is achieved when VHR is used in resistance heated buildings than in district heated buildings. For district heated buildings the primary energy savings are small. VHR systems can give substantial final energy reduction, but the primary energy benefit depends strongly on the type of heat supply system, and also on the amount of electricity used for VHR and the airtightness of buildings. This study shows the importance of considering the interactions between heat supply systems and VHR systems to reduce primary energy use in buildings.

12/01700 Recycling value of building materials in building assessment systems

Saghafi, M. D. *et al. Energy and Buildings*, 2011, 43, (11), 3181–3188.

The selection of green building materials and products is by far the most controversial task in sustainable construction. Determining the merits of building materials and products in terms of their recycling value, which seems to be a simple matter, is a very controversial topic in building assessment systems. This paper suggests a method to assess energy savings by recycling building materials, which can be a potential indicator of recycling worth. The method takes account of material selection, construction and deconstruction technologies, and the frequency of recycling. The result of this study can be used in assessment tools as a factor separate from the embodied energy. Since embodied energy affects the potential recycling energy, another factor is defined, based on these two factors, in order to make it possible to compare and select materials correctly, based on their embodied energy and recycling potential.

12/01701 Reformation of hazardous wastes into useful supporting materials for fast reactor fuels

Osaka, M. *et al. Annals of Nuclear Energy*, 2011, 38, (12), 2661–2666.

Novel concepts for effective utilization of molybdenum (Mo) from nuclear waste and magnesium silicates from hazardous asbestos wastes are proposed. A fast reactor cycle scheme that incorporates each material is described in the present paper. Results of basic studies on several fundamental technologies for the present cycle are given. Basic separation features of Mo by using the LIX63 microcapsule and tertiary pyridine resin were investigated. A simple chemical synthesis route for Mo precursor powder from Mo-containing HNO_3 solution was demonstrated. Effects of impurities in recovered Mo on sintering behaviour of Mo-pellets were experimentally investigated.

12/01702 Renewable biomass production by mixotrophic algae in the presence of various carbon sources and wastewaters

Bhatnagar, A. *et al. Applied Energy*, 2011, 88, (10), 3425–3431.

This study evaluated mixotrophic growth potential of native microalgae in media supplemented with different organic carbon substrates and wastewaters. Three robust mixotrophic microalgae, viz. *Chlamydomonas globosa*, *Chlorella minutissima* and *Scenedesmus bijuga* were isolated after long-term enrichments from industrial wastewater. The mixotrophic growth of these microalgae resulted in 3–10 times more biomass production relative to phototrophy. Glucose, sucrose and acetate supported significant mixotrophic growth. Poultry litter extract (PLE) as growth medium recorded up to 180% more biomass growth compared to standard growth medium BG11, while treated and untreated carpet industry wastewaters also supported higher biomass, compared to BG11 growth with no significant effect of additional nitrogen supplementation. Supplementing treated wastewater and PLE with glucose and nitrogen resulted in 2–7 times increase in biomass relative to the unamended wastewaters or PLE. The consortia of *Chlamydomonas–Chlorella* and *Scenedesmus–Chlorella* were the best for PLE and untreated wastewater respectively, while a combination all three strains was suitable for both PLE and wastewater. These algae can be good candidates for biofuel feedstock generation as they would not require freshwater or fertilizers. Such mixotrophic algal consortia offer great promise for production of renewable biomass for bioenergy applications using wastewaters.

12/01703 System analysis for effective use of palm oil waste as energy resources

Chiew, Y. L. *et al. Biomass and Bioenergy*, 2011, 35, (7), 2925–2935.

Biomass refers to renewable energy sources and comes from biological materials such as trees, plants, manure as well as municipal solid wastes. Effective utilization of biomass as an energy resource requires the use of an optimization model to take into account biomass availability, transportation distances, and the scales and locations of power facilities within a region. In this study, the authors develop a new analytical tool that integrates cost, energy savings, greenhouse gas considerations, scenario analysis, and a geographic information system to provide a comprehensive analysis of alternative systems for optimizing biomass energy production. The goal is to find a system that optimizes the use of biomass waste by analysing the cost, net avoided CO_2 emission, and net energy savings with the objective of profit maximization. In this paper, an application of the modelling tool above is described to one of the fastest growing agriculture industries in Asia, the palm oil industry, for the case of Malaysia. Five scenarios utilizing palm oil waste as energy resources are discussed. The scenario of installing of new combined heat and power (CHP) plants in the region yielded a number of benefits in terms of net energy savings, net avoided CO_2 emission, and profits. The results also demonstrate the benefits of utilizing excess heat for biomass pre-treatment. The choice of a suitable CHP plant scale, management strategies for biomass seasonal availability, and market price of biomass are also important factors for effective use of the biomass in a region.